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Management of coreid bug, *Paradasynus rostratus* Dist. on coconut palm in homesteads having mixed cropping

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ABSTRACT: Chosen neem based botanicals and synthetic chemical pesticides were evaluated against the coreid bug, *Paradasynus rostratus* Dist., a major pest of coconut in Kerala. In laboratory tests, neem seed oil - garlic emulsion 2% and profenophos 0.05% proved effective. Since the alternative hosts, guava, cashew, cocoa and neem in the multiple cropping system play an important role in population build up of the pest, the effect of applying selected treatments on these alternative hosts on the pest population in the coconut was evaluated in a farmer's field. Application of neem seed oil - garlic emulsion 2% + profenophos 0.025% on alternative hosts was the most effective in reducing the extent of *P. rostratus* infestation in the surrounding coconut palms. © 2009 Association for Advancement of Entomology

KEYWORDS: coconut, *Paradasynus rostratus*, pest management

INTRODUCTION

Seasonal and annual agricultural crops are intercropped in the coconut based farming system extensively in the homesteads of Kerala. Recently the main crop, coconut is seen attacked by a complex of pests, the coreid bug, *Paradasynus rostratus* Dist. being one among them. Paul (2006) established the role played by the alternative hosts *viz.*, guava, cashew, cocoa and neem on the population build up of the pest in coconut in the home stead cropping systems. Spraying of 0.1 per cent BHC, 0.05 per cent carbaryl (Kurian *et al.*, 1972), 0.1 per cent endosulfan (Ponnamma *et al.*, 1985) have been recommended for the control of *P. rostratus*. These treatments are not fully effective. Other methods were hence tried and the results are presented in this paper.

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MATERIALS AND METHODS

Six plant based insecticides and five chemical insecticides (Tables 1 and 2) were evaluated through bioassay experiments in the laboratory and best treatments were subjected to further evaluation under field situation in typical homesteads of Kerala.

The insecticide spray materials were prepared by diluting the commercial formulation with required quantity of water. A stock fluid of neem oil - garlic was prepared by mixing 20 ml of neem oil with 50 ml of water containing 5 g of dissolved bar soap and then mixing this with garlic extract prepared by extracting 20 g of ground garlic in 30 ml water. One hundred ml of the stock solution was added to 900 ml of water to get one litre of 2% neem oil - garlic emulsion.

Laboratory evaluation

Spray fluids prepared in required strength were applied on guava fruits. For this experiment, single tender fruit along with the twig was cut from the plant and the cut end of the twig was inserted into water taken in a small conical flask to keep the freshness of the fruit. Those flasks with the twig were then kept in a jar which was closed with muslin cloth. Adequate replication was set up following the above procedure. In the laboratory, each twig was sprayed with required quantity of material using an atomizer and five replications were set up for each treatment. One lot sprayed with water alone was included in treatments as control. The sprayed fruits were made dry under fan and then exposed to five fourth instar nymphs of *P. rostratus* and kept enclosed in a glass jar. The nymphs were collected from a culture of the test insect maintained in the laboratory under ambient temperature and humidity. The percentage mortality was worked out as per Abbott's formula (Abbott, 1925).

Field experiment

The experiment was laid out in farmers field where the known alternative hosts of *P. rostratus viz.*, guava, cashew, cocoa and neem in appropriate stages and the main crop coconut were available in adequate numbers. There were four treatments (Table 3) and each treatment was replicated four times taking one tree as a replication. Alternative host sprayed with water alone was taken as control (four numbers). Unsprayed coconut trees around each sprayed alternative host in the experiment were identified for recording *P. rostratus* incidence and extent of damage. The trees were sprayed with respective pesticide to runoff level.

Four coconut palms around each treated alternative host were selected for taking observations. The first six bunches of the selected palms were tagged with 'sunpac' labels and numbered serially from the sixth bunch onwards to the top, so that the emerging bunches could be serially tagged. The infestation of coreid bug on the third bunche was assessed (Julia, 1978) and the total number of nuts in the bunch and number of nuts damaged by the pest were recorded. The percentage of infested nuts was calculated. The intensity of damage in the infested nuts was graded under six categories based on the methods suggested by Brown (1959): category I - nuts without

scars (uninfested), category II - nuts with 1 to 5 scars (negligible damage), category III - nuts with 6 to 20 scars (mild damage), category IV - nuts with greater than 20 scars in a single ring round the nut (moderate damage), category V - nuts with greater than 20 scars distributed more or less all over the nut (heavy damage), and category VI - nuts heavily scarred in which the endosperm failed to develop (severe damage). The difference between categories IV and V depends on whether the nut has been attacked during its development only once (category IV) or repeatedly (category V) resulting in lesser and greater reduction of kernel, respectively.

The yield Index (YI) was worked out as YI = W1X1 + W2X2 + W3X3 + W4X4 + W5X5 + W6X6 where W1 to W6 were the weights given to the number of damaged nuts in the respective classes and the weights were 6, 5, 4, 3, 2 and 1, respectively, in each damage category and X1 to X6 represented the number of nuts in each damage category, respectively.

RESULTS

Laboratory evaluation

The results of laboratory evaluation of botanicals and chemical insecticides are presented in Tables 1 and 2 respectively.

The number of feeding punctures in neem seed oil - garlic emulsion 4% and 2% and neem seed oil 4% and 2% treated fruits was negligible (Table 1). More feeding punctures were observed in NeemAzal 0.2%, NeemAzal 0.4% and Econeem 0.2% treated fruits and they were on par.

The mortality of coreid bug nymphs was more when released on neem seed oil -garlic emulsion 2 and 4% (46.67% each) treated fruits and it was on par with the treatments, Econeem 0.4% (30%), Achook 0.4% (30%) and Nimbecidine 0.4% (23.33%). Lower percentage mortality was recorded from neem seed oil 2% (20%), Neem Azal 0.4% (6.67%) and Econeem 0.2% (3.33%) treatments, which were on par.

Among the chemicals, profenophos 0.1% gave the highest kill of 86.12% (Table 2). It was on par with 0.05% profenophos. It was also on par with quinalphos 0.1%, chlorpyriphos 0.1%, triazophos 0.1% and acephate 0.1%. The lower doses of the above insecticides were significantly inferior to the above mentioned treatments. Profenophos 0.05% which ranks high may be chosen as the best treatment against *P. rostratus* since it is equally effective at the lower dose.

Field evaluation

Infestation level

The data are presented in Table 3.

Trees around guava: Lower infestation was observed in coconut palms around guava trees treated with profenophos 0.05% followed by coconut palms around plants treated with neem seed oil - garlic emulsion 2% + profenophos 0.025%. The

TABLE 1. Antifeedant effect and toxicity of neem based botanicals on *Paradasynus rostratus*

Treatment	% a.i.	Antifeedant action: No. of feeding punctures on guava fruits 24 h after release	Toxicity: Mortality % 48 h after release
Achook	0.2	4.00 (2.24)	0.00 (1.00)
Achook	0.4	4.33 (2.31)	30.00 (5.56)
Nimbecidine	0.2	3.67 (2.16)	0.00 (1.00)
Nimbecidine	0.4	1.67 (1.63)	23.33 (4.93)
Econeem	0.2	3.00 (2.00)	3.33 (2.08)
Econeem	0.4	4.33 (2.31)	30.00 (5.57)
NeemAzal T/S	0.2	2.33 (1.99)	0.00 (1.00)
NeemAzal T/S	0.4	2.67 (1.91)	6.67 (2.19)
Neem seed oil	2	0.67 (1.28)	20.00 (4.58)
Neem seed oil	4	0.33 (1.14)	23.33 (4.93)
Neem seed oil-garlic	2	0.33 (1.14)	46.67 (6.87)
Neem seed oil-garlic	4	0.00 (1.00)	46.67 (6.87)
CD (0.05)		0.31	3.07

Figures in parentheses are $\sqrt{x+1}$.

TABLE 2. Effect of synthetic insecticides on *Paradasynus rostratus*

Treatment	% a.i.	Percentage mortality observed after various intervals (h): 12	24	48	72
Triazophos	0.05	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	13.33 (3.39)
Triazophos	0.10	0.00 (1.00)	3.33 (1.77)	33.33 (6.01)	66.67 (8.11)
Quinalphos	0.05	6.67 (2.54)	13.33 (3.39)	26.67 (5.24)	43.33 (6.65)
Quinalphos	0.10	16.67 (3.72)	20.21 (4.01)	36.67 (6.04)	46.67 (6.90)
Chlorpyriphos	0.05	3.33 (1.77)	6.66 (2.19)	16.67 (3.72)	26.67 (5.24)
Chlorpyriphos	0.10	20.01 (4.49)	26.67 (5.24)	36.67 (6.13)	56.67 (7.59)
Profenophos	0.05	16.67 (3.72)	20.67 (4.24)	50.01 (7.08)	79.46 (8.97)
Profenophos	0.10	30.01 (5.52)	46.67 (6.90)	63.33 (7.94)	86.42 (9.35)
Acephate	0.05	0.00 (1.00)	6.67 (2.54)	16.67 (4.16)	43.33 (6.62)
Acephate	0.10	3.33 (1.77)	13.33 (3.39)	16.67 (4.16)	50.01 (7.08)
Control		0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
CD (0.05)		2.02	2.27	1.80	2.08

Figures in parentheses are $\sqrt{x+1}$.

infestation in palms around neem seed oil - garlic emulsion 2% treated guava trees and untreated guava did not differ significantly.

Trees around cashew: The infestation of the coreid bug was lower in neem seed oil -garlic emulsion 2% + profenophos 0.025% treatment which was on par with profenophos 0.05%. Higher infestation was observed in palms around cashew trees treated with neem seed oil - garlic emulsion 2% palms around untreated cashew.

TABLE 3. Extent of infestation of *Paradasynus rostratus* on coconuts around pesticide treated alternative hosts

Treatment	Mean of extent of infestation (%) at different months after spraying			
	Guava	Cashew	Cocoa	Neem
Neem seed oil – garlic 2 %	50.95 (7.18)	49.12 (7.07)	67.37 (8.26)	59.07 (7.73)
Profenophos 0.05 %	17.22 (4.26)	22.34 (4.83)	34.31 (5.93)	27.97 (5.38)
Neem seed oil - garlic 2% + Profenophos 0.025 %	23.01 (4.89)	17.47 (4.29)	30.07 (5.56)	25.46 (5.08)
Control	62.50 (7.86)	65.02 (8.13)	62.40 (7.99)	60.58 (7.84)
CD (0.05)	1.057	0.420	1.109	0.733

Values in parentheses are adjusted means transformed to their square root.

Trees around cocoa: Profenophos 0.05% and neem seed oil - garlic emulsion 2% + profenophos 0.025% significantly reduced the infestation in coconut around treated cocoa trees. The treatments were statistically on par. The infestation noticed in palms around neem seed oil - garlic emulsion 2% treated cocoa was statistically similar to those in coconut around untreated cocoa.

Trees around neem: Lower infestation was observed in coconut palms near neem trees treated with neem seed oil -garlic emulsion 2% + profenophos 0.025% and profenophos 0.05%. The infestation in coconut palms around neem treated with neem seed oil - garlic emulsion 2% was significantly higher and similar to those around untreated trees.

Impact on yield

The data are presented in Table 4.

Trees around guava: The highest yield index (YI) of 74 was obtained in coconut palms around guava sprayed with neem seed oil- garlic emulsion 2% + profenophos 0.025% followed by palms around guava sprayed with profenophos 0.05%(67). The YI of palms around guava plants sprayed with neem seed oil- garlic emulsion 2% alone was only 45.

Trees around cashew: A similar trend was seen in nut yield from palms around cashew tree treated with insecticides. The highest YI (56) was recorded in palms around cashew sprayed with neem seed oil- garlic emulsion 2% + profenophos 0.025%, followed by palms around cashew treated with profenophos 0.05% (35).

TABLE 4. Damage to mature nuts caused by *Paradasynus rostratus* and yield index in coconut palms around treated alternative hosts

Treatment	No. of nuts in each damage category						Yield Index (YI)
	I	II	III	IV	V	VI	
Guava							
NSG – 2 %	2	2	1	4	3	1	45
Profenophos - 0.05 %	8	3	1	0	0	0	67
NSG-2 % + profenophos 0.025 %	7	4	3	0	0	0	74
Control	1	1	2	1	3	3	31
Cashew							
NSG – 2%	0	0	4	0	2	2	22
Profenophos - 0.05%	5	1	0	0	0	0	35
NSG-2% + profenophos 0.025%	8	0	2	0	0	0	56
Control	0	1	0	0	0	3	8
Cocoa							
NSG – 2%	0	4	0	2	3	0	32
Profenophos - 0.05%	2	5	3	0	0	0	49
NSG-2% + profenophos 0.025%	8	0	0	0	0	0	48
Control	0	0	0	2	3	0	12
Neem							
NSG – 2%	0	2	0	0	2	5	9
Profenophos - 0.05%	8	2	0	1	0	0	61
NSG-2% + profenophos 0.025%	9	1	0	2	0	0	65
Control	0	0	2	4	2	0	24

NSG – Neem seed oil–garlic emulsion

Trees around cocoa: The YI was more or less similar in palms around cocoa treated with profenophos 0.05% (49) and neem seed oil- garlic emulsion 2% + profenophos 0.025%.The YI was less (32) in palms around cocoa treated with neem seed oil- garlic emulsion 2%.

Trees around neem: The highest YI of 65 was obtained in coconut palms around neem sprayed with neem seed oil - garlic emulsion 2% + profenophos 0.025% followed by palms around neem sprayed with profenophos 0.05%(61). The lowest YI was recorded in palms around neem sprayed with neem seed oil - garlic emulsion 2 % (9).

DISCUSSION

In the laboratory, neem seed oil – garlic emulsion 2% and profenophos 0.05% proved to be the best insecticides. Both the insecticides when applied alone and in combination on the alternative hosts reduced the infestation of the pest in the surrounding palms. An overall perusal of the results revealed that the application of combination of neem seed oil - garlic emulsion 2% + profenophos 0.025% on the alternative hosts was most effective in reducing the extent of coreid bug infestation.

The present study is in confirmation with the observations made by Mohan (2001). She observed lower infestation in coconut palms treated with neem seed oil - garlic 2% + endosulfan 0.1% compared to the other treatments. Efficacy of neem seed oil-garlic emulsion 2% against the coconut eriophyid mite had been reported earlier (KAU, 2002). The combination of both botanical and chemical was effective as neem has a potentiating effect on chemical pesticides (Singh and Singh, 1987). The antifeedant action of neem inhibited the feeding of the coreid bug which rendered it more susceptible to the toxic action of the chemical. Adoption of control measures on the alternative hosts against the coreid bug had an appreciable impact on the extent of damage and consequently yield of mature nuts. Categorization of the harvested nuts into different damage classes and YI of coconut palms revealed that the coreid bug caused only negligible to mild damage on coconut palms around alternative host sprayed with profenophos 0.05% and neem seed oil - garlic emulsion 2% + profenophos 0.025%. Thus the most effective and economic treatment against coreid bug proved to be neem seed oil - garlic emulsion 2% + profenophos 0.025%. The stratification of the coconut palm and other alternative hosts in the multiple cropping system greatly influences the nature and distribution of the bug. This was perhaps the most important factor in the development and establishment of an ecological niche for the coreid bug. Hitherto, spraying of insecticides on coconut is the measure adopted for managing the pest when infestation is severe. However, the single stem stand of the palm makes the control of a highly mobile insect like the coreid bug a difficult task. Lack of skilled climbers for conduct ng plant protection operations in coconut too makes this an expensive proposition. In this context, a viable strategy is to utilize the alternative hosts to contain the coreid bug. Moreover, the susceptibility of alternative hosts to coreid bug indicated their propensity as trap crops.

The effective implementation of the technology is dependent on a thorough knowledge of the phenology of the alternative hosts *viz*., flushing, flowering and fruiting, which synchronize with the infesting stages in the coreid bug's life cycle. The life cycle of the pest, damage symptoms caused on alternative hosts and coconut as well as migration of the pest has to be studied and knowledge disseminated among the coconut farming community. Regular monitoring of alternative hosts should be done in the homesteads to detect population build up. The pest can be controlled on the alternative hosts by application of neem seed oil - garlic emulsion 2% + profenophos 0.025%. However, the use of profenophos has to be recommended with utmost care especially in the homesteads.

Integrated pest management seeks to integrate strategies that are practical, effective, economical and protective of both public health and the environment. The present study could establish plant protection operations on alternative hosts against coreid bug as a cost effective and viable option compared to those in coconut. This strategy would be an invaluable component for integrated management of the pest on coconut palms.

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REFERENCES

Abbott W. S. (1925) A method of computing the effectiveness of an insecticide. Journal of Economic Entomology, 18: 265–267.

Brown E. S. (1959) Immature nut fall of coconuts in the Solomon Islands. I-Distribution of nut fall in relation to that of *Amblypelta* and of certain species of ants. Bulletin of Entomological Research, 50: 97–133.

Julia J. F. (1978) The coconut bug, *Pseudotheraptus* sp. II – Method of integrated control in the Ivory Coast. Oleagineux, 33(3): 117–118.

KAU (2002) *Package of practices Recommendations 'Crops' 2002*, Directorate of Extension, Mannuthy 680 651, Thrissur, Kerala, India, p. 278.

Kurian C., Abraham V. A. and Koya K. M. A. (1976) A new enemy of coconut in India. Indian Farming, 27: 12.

Kurian C., Pillai G. B., Abraham V. A. and Mathen K. (1972) Record of a coreid bug (nut crinkler) as a new pest of coconut of India. Current Science, 41: 37.

Mohan P (2001) Management of the sucking pest complex, coconut eriophyid mite, coreid bug and button mealy bug infesting coconut bunches *M.Sc. (Ag.) Thesis*, Kerala Agricultural University, Thrissur, p. 88.

Paul A (2006) Population dynamics, intensity of damage and management of the coreid bug *Paradasynus rostratus* Dist. *Ph.D. Thesis*, Kerala Agricultural University, Thrissur.

Ponnamma K. N., Kurian C., Sukumaran A. S. and Koya K. M. A. (1985) Field evaluation of BHC, carbaryl and endosulfan for the control of the coconut coreid bug *Paradasynus rostratus* Distant. Indian Coconut Journal, 15: 10–11.

Singh B and Singh A. P. (1987) Joint action of neem kernel suspension with some insecticides against *Schistocerca gregaria* Forsk. Neem Newsletter, 6(4): 38–40.

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Screening of *Bacillus thuringiensis* Berliner isolates from Kerala for bioefficacy against *Spodoptera litura* Fabricius

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ABSTRACT: Bio-efficacy of 20 native isolates of *B. thuringiensis* was evaluated against second instar larvae of *S. litura* through preliminary screening. The isolates, KAU-11, KAU-51 and KAU-166 were found pathogenic to the test insect. All these isolates were equal in effectiveness with the standard strain, HD-1. The lowest LC_{50} value was obtained for KAU-51. But the standard strain HD-1 gave lower LT_{50} values.
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KEYWORDS: *Bacillus thuringiensis*, *Spodoptera litura*, Kerala, Western Ghats, LC_{50}, LT_{50}

INTRODUCTION

The entomopathogenic bacterium, *B. thuringiensis* is an ideal candidate for management of several insect pests. Nagamatsu *et al.* (1998) reported that the production of insecticidal crystal proteins (ICPs) or δ-endotoxin by the sporulating cells of this bacterium is responsible for the insecticidal activity. The development of resistance to *B. thuringiensis* based bioinsecticides is a serious threat. Hence isolation and evaluation of new native isolates of *B. thuringiensis* for increased virulence and for novel activity against target pests is essential. We report the effectiveness of certain *B. thuringiensis* isolates from the Western Ghats of Kerala against the tobacco caterpillar, *Spodoptera litura*.

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MATERIALS AND METHODS

Twenty native isolates of *B. thuringiensis* collected from soil from different places in the Western Ghats of Kerala (Table 1) and the standard reference strain, HD-1 (obtained from Centre for Plant Biotechnology and Molecular Biology, College of Horticulture, Kerala Agricultural University, Thrissur) were used in the present study.

The 20 native isolates and the standard strain, HD-1 were maintained in LBA medium (Miller, 1972) and T3 medium (Travers *et al.*, 1987). For examining the presence of crystal protein inclusions, staining with Coomasie brilliant blue was done as described by Sharif and Alaeddinoglu (1988) and the smear was observed under 100X objective of a compound binocular microscope. For preliminary screening, the spore count of all the bacterial cultures were taken with haemocytometer and the concentration of the cultures were adjusted to 1×10^9 spores per ml using 0.1% teepol solution prepared in sterile distilled water. The screening was done against second instar larvae of *S. litura* which were reared in semi synthetic diet (Ballal, 2004). For the bioassay, castor leaf discs of 3 cm diameter were used. One hundred μl of the spore suspension was applied uniformly on the upper and lower surface of the leaf disc and air dried. Thirty pre starved (for 6 h) second instar larvae were used for each treatment. Castor leaf discs treated with 0.1% teepol solution alone was kept as control.

Observation for larval mortality was taken at 24 h interval for seven days. The isolates that showed a minimum of 10% mortality were selected for standardized bioassay.

Bacillus thuringiensis isolates which showed more than 10 % mortality against *S. litura* were selected for the standardized bioassay. HD-1 was used as the standard. Five different concentrations of spore suspensions, namely, 1×10^7, 1×10^8, 1×10^9, 1×10^{10} and 1×10^{11} spores per ml were prepared by serial dilution. Castor leaf discs of 3 cm diameter were dipped in spore suspensions of required concentrations for 30 s and air dried. Thirty pre-starved second instar larvae were used for the treatment. Castor leaf discs dipped in 0.1% teepol solution were fed to larvae in control. The experiment was carried out in CRD (Completely Randomized Block Design). The observations on larval mortality were recorded upto seven days after treatment. The per cent mortality was analysed by ANOVA after square root transformation. LC_{50} values for the isolates and the standard strain HD-1 were calculated by Finney's method of Probit Analysis (Finney, 1971) and LT_{50} values by graphical method.

RESULTS AND DISCUSSION

Three isolates namely, KAU-11, KAU-51 and KAU-166 gave more than 10% mortality of *S. litura* larvae (Table 1). KAU-166 caused the highest mortality of 86.7% followed by KAU-51 (80.0%) and KAU-11 (76.7%). Only these three, among the 20 isolates produced bipyramidal crystals, suggesting that bipyramidal crystals are characteristic of lepidopteran specific isolates. Toxicity of *B. thuringiensis* isolates that produced bipyramidal crystals, against *Plutella xylostella* was also reported by Asokan and Puttaswamy (2007).

TABLE 1. Mortality caused by different isolates of *Bacillus thuringiensis* to 2nd instar larvae of *Spodoptera litura*

Isolates of Bt	Collected from	Crystal protein morphology	Cumulative % mortality at 7 DAT
KAU-1	Idukki	Spherical	0.0
KAU-11	Calicut	Bipyramidal	76.7
KAU-18	Calicut	Triangular	0.0
KAU-19	Calicut	Irregular + Spherical	0.0
KAU-33	Idukki	Spherical	0.0
KAU-37	Idukki	Irregular	0.0
KAU-45	Idukki	Spherical	3.0
KAU-50	Idukki	Spherical	0.0
KAU-51	Idukki	Bipyramidal	80.0
KAU-56	Calicut	Irregular	0.0
KAU-66	Pathanamthitta	Spherical	0.0
KAU-67	Pathanamthitta	Spherical	0.0
KAU-95	Kollam	Kollam	0.0
KAU-116	Kollam	Kollam	0.0
KAU-127	Palakkad	Palakkad	0.0
KAU-130	Palakkad	Palakkad	3.0
KAU-133	Palakkad	Palakkad	0.0
KAU-166	Palakkad	Palakkad	86.7
KAU-189	Palakkad	Palakkad	0.0
KAU-203	Palakkad	Palakkad	0.0
HD-1 (Reference standard) (*B. thuringiensis* subsp. *kurstaki*)			96.7

TABLE 2. Cumulative mortality of *Spodoptera litura* at 7 DAT in different treatments

Isolates	Concentration (spores/ml)				
	1×10^7	1×10^8	1×10^9	1×10^{10}	1×10^{11}
KAU-11	76.7(8.75)	76.7(8.75)	80.0(8.92)	83.3(9.13)	90.0(9.48)
KAU-51	63.3(7.98)	66.7(8.13)	80.0(8.93)	80.0(8.96)	83.3(9.15)
KAU-166	66.7(8.17)	70.0(8.38)	83.3(9.13)	83.3(9.14)	93.3(9.67)
HD-1	76.7(8.78)	83.3(9.10)	93.3(9.68)	96.7(9.85)	100.0(10.02)

The differences between treatments and between concentrations were not statistically significant. Figures in parentheses are square root transformed values.

In the standardized bioassay the per cent mortality varied in different concentrations of bacterial isolates, at different intervals after treatment. Larval mortality increased with time. The lowest mortality was observed on the first day (24 h). No mortality was recorded in control. Statistical analysis of cumulative mortality at seven days after treatment showed that all the isolates were on par in effectiveness (Table 2). There was no significant difference between concentrations and between treatments.

TABLE 3. Median Lethal Time (LT_{50}) of different *Bacillus thuringiensis* isolates for different concentrations

Concentration (spores/ml)	LT_{50} (h after treatment)			
	KAU-11	KAU-51	KAU-166	HD-1
1×10^7	80.5	96.0	89.3	68.0
1×10^8	96.0	66.6	66.4	57.5
1×10^9	72.6	55.2	63.6	48.0
1×10^{10}	81.6	57.0	59.4	44.4
1×10^{11}	72.0	48.0	56.0	45.4

TABLE 4. Median lethal concentration (LC_{50}) of selected *Bacillus thuringiensis* isolates

Isolates	LC_{50} (spores/ml)
KAU-11	1.2589×10^6
KAU-51	6.3095×10^4
KAU-166	7.9432×10^4
HD-1	1.5849×10^5

The LT_{50} values were lower for HD-1 when compared to other isolates, for all concentrations (Table 3). This showed the effectiveness of the standard strain to cause quicker death. $LC_{50}$was lowest (6.3095×10^4) for KAU-51, followed by KAU-166, HD-1 and KAU-11 (Table 4). The lowest LC_{50} value was obtained for KAU-51 which indicated the comparatively high effectiveness of this isolate. The equal effectiveness of the isolates with the standard strain reveals the possibility of using these isolates to overcome the chance of insect resistance to the accepted strains of *B. thuringiensis*. The efficacy of KAU-11, KAU-51 and KAU-166 against other lepidopteran pests needs to be studied.

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REFERENCES

Asokan R. and Puttaswamy (2007) Isolation and characterization of *Bacillus thuringiensis* Berliner from soil, leaf, seed dust and insect cadaver. Journal of Biological Control, 21(1): 83–90.

Ballal C. R. (2004) Mass production of *Helicoverpa armigera* and *Spodoptera litura* and their parasitoids. In: *Training programme on Emerging Trends in Biological Control*, Rao M. S. and Rabindra R. J. (Eds). Project Directerate of Biological Control, Bangalore, p. 135.

Finney D. J. (1971) *Probit Analysis*, Cambridge University Press, p. 318.
Miller J. H. (1972) *Experiments in Molecular Genetics*, Cold Spring Harbor Laboratory, p. 466.
Nagamatsu Y., Koike T., Saski K., Yoshimoto A. and Furukawa Y. (1998) The cadherin like protein is essential to specificity determination and cytotoxic action of the *Bacillus thuringiensis* insecticidal toxin Cry1Aa. FEBS Letters., 46: 385–390.
Sharif F. A. and Alaeddinoglu (1988) A rapid and simple method for staining of the crystal protein of *Bacillus thuringiensis*. Indian Journal of Microbiology, 3: 227–229.
Travers R. S., Martin P. A. and Reichelderfer C. F. (1987) Selective process for efficient isolation of soil *Bacillus* sp. Applied and Environmental Microbiology, 53: 1263–1266.

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A comparison of dung beetle (Coleoptera: Scarabaeidae) communities sampled by two types of traps

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ABSTRACT: Dung beetle communities sampled by two types of traps, i.e. pitfall bait traps and natural dung pad, were compared in a cultivated area of Kurukshetra, Haryana, India. Pitfall traps were baited with 100–150 g of fresh cattle dung. Sampling was carried out for a six month period. A total of 907 individuals of 25 species of dung beetles were collected from both the traps – 595 individuals comprising 22 species from pitfall traps and 312 individuals comprising 17 species from dung pads. Out of the 25 species, 14 were common to both types of traps; eight were found only in pitfall traps, and three only in dung pads. Both in terms of the number of species and the number of individuals, pitfall trap was more efficient although three species were not collected in pitfall traps. The largest number of individuals was collected in the month of June, followed by August, in both the trap types. The most abundant species were *Onthophagus falsus*, followed by *O. mopsus*, *O. ramosellus*, *O. bonasus*, *Onitis philemon* and *Onthophagus catta*, in that order.
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KEYWORDS: Coleoptera, Scarabaeidae, dung beetle, natural dung pad, pitfall trap

INTRODUCTION

To study different aspects of the ecology of dung beetles, it is important to set up standard sampling methods that can achieve unbiased results. Various methods have been used like light trap by William (1944), pitfall bait traps and natural dung pad collection by Doube and Giller (1990) for sampling dung beetles. Dung pad baits provide only an estimate of the species and number of beetles occupying the pad at the time of sampling. Doube and Giller (1990) found pitfall traps the most commonly used trapping method because the beetles can be rapidly recovered for counting and the sampling is not influenced by the nature of the bait. In the dung pad method, formation of a dry crust on the pad and dung removal for sampling decrease the number of colonists. The objectives of the present study were to (1) estimate the total

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number of species and individuals of dung beetles in the study area, and (2) compare the efficacy of two types of traps for sampling the dung beetle community.

METHODS

The study site was situated approximately 25 km north of Kurukshetra, Haryana (29°58 N latitude and 76°51 E longitude) at about 250 m a.s.l. The study area was primarily under cultivation, with a good population of domestic cattle. Two types of trapping methods were tried (i) Pitfall bait traps based on Tyndal Biscoe *et al.* design (1981), with 100–150 g fresh cattle dung per trap. Five such traps were buried in the field keeping the upper edge of the traps in level with the ground. On a fixed day of the week the traps were baited in the evening and the beetles were collected after 24 h. (ii) Collection from natural dung pads. Five natural dung pads were identified and the beetles were collected from them by hand picking. Collection from pitfall bait traps and natural dung pads were made on the same day. The sampling was carried out from May to October 2000. Collected beetles were narcotized with ethyl acetate and then oven dried at 60 °C for 48 h. The beetles were identified with the help of identification keys and descriptions of Indian fauna given by Arrow (1931), Mittal (1975, 1981, 1984, 1993)) and Gupta (1986).

Large number of Scarabeid beetles including telecoprids (ball rollers), paracoprids (tunnellers) and endocoprids (nesting in pads) was captured in both trap types. Data were prepared month-wise to compare the two beetle communities by using paired t-test. Pearson's Correlation coefficient was calculated to measure the association between two variables i.e. number of species and number of individuals. The significance (probability) of the correlation coefficient was determined from the t-statistic. Linear regression was used to examine whether the independent variable (number of species) could predict the dependent variable (number of individuals) or not.

RESULTS AND DISCUSSION

A total of 907 individuals of 25 species of dung beetles were trapped in the pitfall bait traps and natural dung pads during the six months of study (Table 1). Out of the 25 species, 14 were common to both types of traps; eight were found only in pit fall traps, and three only in dung pads. Out of the total of 907 individuals caught, pitfall traps caught 595 and the dung pads, 312. Thus both in terms of the number of species and the number of individuals, pitfall trap was more efficient. Paired t test showed that the difference between pitfall bait traps and dung pads was significant ($t = 2.237$, $df = 5$, at 95% confidence, two tailed probability = 0.076). Doube and Giller (1990) also found that the trap type influenced the number of some species.

The largest number of individuals was collected in the month of June in both the trap types, followed by August and then September in pitfall traps, and August as well as May and then September in dung pads (figure 1).

TABLE 1. Comparison of dung beetles sampled by two types of traps

Species	No. of beetles collected over 6 months		
	Pitfall trap	Natural dung pad	Total
Aphodius campestris	7	4	11
A. crenatus	2	12	14
A. lividus	18	3	21
A. marginellus	2	7	9
A. moestus	16	18	34
A. urostigma	8	0	8
Catharcius inermis	0	1	1
Drepanocerus setosus	1	0	1
D. sinicus	1	0	1
Gymnopleurus parvus	1	0	1
Hybosorus orientalis	3	34	37
Oniticellus cinctus	0	3	3
O. pallens	13	4	17
O. pallipes	6	0	6
O. spinipes	1	0	1
Onitis philemon	38	63	101
O. subopacus	0	1	1
O. virens	1	3	4
Onthophagus bonasus	58	61	119
O. catta	31	46	77
O. falsus	144	34	178
O. mopsus	124	12	136
O. ramosellus	118	6	124
O. sternalis	1	0	1
Rhyssemus germanus	1	0	1
Total	595	312	907

The most abundant species were *Onthophagus falsus*, followed by *O. mopsus, O. ramosellus, O. bonasus, Onitis philemon* and *Onthophagus catta*, in that order. Nine species were trapped only once.

A simple linear regression was performed on six months data collected from pitfall traps and from natural dung pads to determine the type of relationship between number of species and number of individuals. For both pitfall trap ($t_{(4)} = 2.810$, $p = 0.05$) and natural dung pad collection ($t_{(4)} = 3.083$, $p = 0.04$) the t- statistic for the slope was significant at 0.05 critical alpha level. Thus we reject the null hypothesis and conclude that there was a positive relationship between number of species and number of individuals. Furthermore, 66.4% and 70.4% of the variability in number of individuals could be explained by number of species in pitfall trap and natural dung pad collection respectively. Pearson's Correlation coefficient was calculated to know the association between number of species and number of individuals trapped.

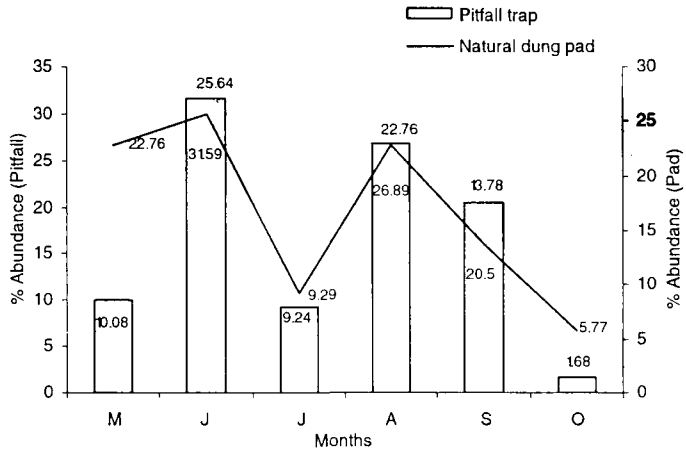

FIGURE 1. Comparison of % abundance of dung beetles in two types of traps.

t-statistic was calculated to know the significance of the correlation coefficient. Data collected from both the trapping methods showed a significant correlation coefficient between number of species and number of individuals i.e. $0.815_{(Pit)}$ and $0.839_{(Pad)}$.

In conclusion, this study shows that pitfall trapping is superior to collection from dung pad as it yielded greater number of species as well as individuals. However, it does not reveal the complete population of the area, as some species (*Catharcius inermis, Onitis subopacus* and *Oniticellus cinctus*) were collected only from natural dung pads. Therefore pitfall trapping with collection from natural dung pad will give better result. Both the types of traps, however, reflected the relative numerical abundance of the dominant species. It may also be noted that in the month of May, natural dung pad yielded greater number of beetles than pitfall trap, probably because of prolonged effectiveness of dung.

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REFERENCES

Arrow G. J. (1931) *The Fauna of British India Including Ceylon and Burma, Col. Lamella. III (Coprinae)*, Tayler and Francis, London, p. 428.

Doube B. M. and Giller S. (1990) A comparison of two types of trap for sampling dung beetle populations (Coleoptera: Scarabaeidae). Bulletin of Entomological Research, 80: 259–263.

Gupta A. K. (1986) Studies on dung beetles (Coleoptera: Scarabaeidae: Laparosticti) of North West India *Ph.D. Thesis*, Kurukshetra University, Kurukshetra.

Mittal I. C. (1975) Studies on the taxonomy of the family Scarabaeidae (Coleoptera) of Haryana and surrounding areas *Ph.D. Thesis*, Kurukshetra University, Kurukshetra.

Mittal I. C. (1981) Scarabaeids of Haryana and surrounding areas. Bulletin of Entomological Research, 22: 35–40.

Mittal I. C. (1984) On the taxonomy of Scarabaeidae (Coleoptera) with a key to the Indian subfamilies. Entomol. Blatter, Bd. 80, Heft 1. Seite, 7–25.

Mittal I. C. (1993) New Aphodiinae species (Coleoptera: Scarabaeidae) from India. Journal of Entomological Research, 17(4): 239–245.

Tyndal Biscoe M., Wallace M. M. H. and Walker J. M. (1981) An ecological study of an Australian dung beetle, *Onthophagus granulatus* Boheman (Coleoptera: Scarabaeidae), using physiological age-grading techniques. Bulletin of Entomological Research, 71: 137–152.

William C. B. (1944) An analysis of four years captures of insects in a light TrapII. Trans. R. Entomol. Soc., 90: 227–306.

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Bothrideridae of Andaman and Nicobar Islands, India with description of a new species (Coleoptera: Cucujoidea)

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ABSTRACT: Four species of Bothrideridae *viz.*, *Pseudobothrideres velatus* Grouvelle, *Pseudobothrideres abbreviatus* sp. nov., *Erotylathris philippinensis* Motschulsky, and *Machlotes porcatus* Pascoe are recorded from Andaman and Nicobar Islands. A description of the new species is given. © 2009 Association for Advancement of Entomology

KEYWORDS: Coleoptera, Bothrideridae, *Pseudobothrideres* Grouvelle, new species, Nicobar Is.

INTRODUCTION

The Bothrideridae is a moderately large family of the superfamily Cucujoidea with about 300 species which are represented in all major biogeographic regions of the world. The constitution of the Bothrideridae (and related family Cerylonidae) remained complex and had undergone changes at times. Most of the species currently placed in two taxa were variously placed in several subgroups of the family Colydiidae by most coleopterists since Erichson (1845). But they cannot be placed with true colydiids in one assemblage owing to the position of antennal base, structure of aedeagus and characters of larva. The Bothrideridae was first proposed by Craighead (1920) on the basis of larval features. However, over the years various genera which possessed features like, 4-segmented tarsi and clubbed antennae were placed in Colydiidae (Lawrence, 1980). This was followed in the *Coleopterorum Catalogus* by Hetschko (1930) and Crowson (1955) with several modifications. Several workers on Coleoptera considered the Colydiidae as set out in the *Coleopterorum Catalogus* to be an assemblage containing parts of several families of beetles. Subsequently, Pal and Lawrence (1986) placed the genera close to *Bothrideres* Dejean (Bothriderinae, *sensu*

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(Crowson, 1955)) in a separate family and divided the family into four subfamilies *viz.*, Bothriderinae, Annomatinae, Teredinae and Xylariophilinae.

The bothriderids are small to moderately large beetles, with elongate and subcylindrical to slightly flattened body which inhabit dead and fungus infested wood, under bark. Several species are predators on wood inhabiting larvae of insects. About 12 species have so far been recorded from India with no reports from the insular parts. Recently, some beetles of this family were collected from Andaman & Nicobar Islands. The present paper incorporates the taxonomic inventory of this material representing four species including a new species of *Pseudobothrideres* Grouvelle.

SYSTEMATICS

Family Bothrideridae

Subfamily Bothriderinae

Genus ***Pseudobothrideres*** Grouvelle

1908. *Pseudobothrideres* Grouvelle, *Annls. Soc. Ent. Fr.*, **77**: 438 [Type-species: *Pseudobothrideres neglectus* Grouvelle].

Distribution: Africa, Australia, Pacific Islands, South and Southeast Asia [Indonesia, Malaysia, Philippines, Thailand, Vietnam, India].

Pseudobothrideres velatus *Grouvelle*

1908. *Pseudobothrideres velatus* Grouvelle, *Annls. Soc. Ent. Fr.*, **77**: 441.

New record: Material: 1 ex. (sex. indet.), India, Andaman Is., South Andaman, Lorazig, 10 km. O-Nilambur, 22.ii.2000, T.K. Pal & party, *ex.* under bark.

Distribution: India: Sikkim, Tamil Nadu, Andaman Is.; Thailand, Vietnam.

Pseudobothrideres abbreviatus *sp. nov.*

General appearance (Fig. 1a, b) elongate-oblong, dark brown, moderately shiny.

Head transverse, anterior margin of clypeus slightly arcuate, no marked elevation or depression on frons; eyes more than one-third as long as head, post-ocular temple long and parallel-sided; antenna slightly longer than head, scape large and subglobular, pedicel distinctly narrower and shorter than scape, segment 3 shorter than pedicel and about as broad as long, segments 4–8 subequal and slightly widening anteriorly, segment 9 slightly wider than preceding segment, club more or less abrupt, basal segment of club (segment 10) broad and transverse, apical segment (segment 11) shorter and narrower than penultimate segment; frons with punctures distinctly coarser than those of clypeus, smaller and somewhat elongate anteriorly and antero-laterally where they are more closely set than on top, punctures separated on top by 0.5–1.0 diameter.

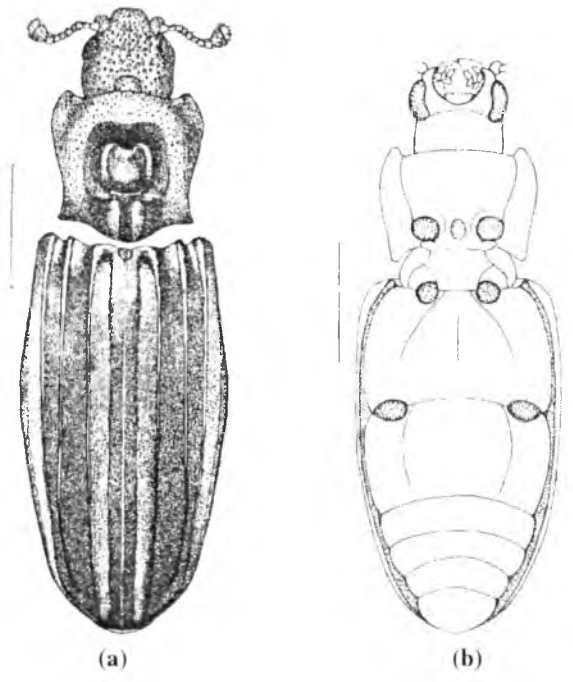

FIGURE 1. *Pseudobothrideres abbreviatus* sp. nov. a, Dorsal view; b, ventral view (scale = 1.0 mm)

Prothorax almost subquadrate (0.97:1.00), subtrapezoidal, front margin somewhat excavated with distinctly produced front angles; sides arcuate and sinuate prebasally, finely margined, hind angles less prominent; basal margin emarginate medially and slightly sinuate on either side; medio-basal sulcus elongate and quite prominent, with median and sublateral grooved extensions to base, median tubercle elongate and slightly indented anteriorly; punctures on tubercle and remaining part of pronotum rather finer than those on frons.

Scutellum about as broad as long and angulate posteriorly.

Elytra about twice as long as their greatest combined width (1.0:2.0), very slightly broadened from rounded shoulders to about middle, narrowed thence to obtusely rounded apical borders; sutural carinae broadly and shallowly raised, more strongly so on apical declivity, entire; carinae of third intervals also entire, shallowly raised on disc and more strongly so on apical declivity, joined at basal borders of sutural carinae; carinae of fifth intervals about as wide as third, more prominently raised, ending freely at base and terminate shortly before reaching apical borders; carinae of seventh and ninth intervals narrowly raised, joined at shoulders and shortly before apices, combined carinae reaching apical borders; even intervals flat, second interval

more deeply excavate along apical declivity; almost impunctate, only except minute punctures on raised intervals near apical declivity; ventrally almost impunctate,

Measurements of holotype: Total length 5.0 mm., width of head across eyes. 0.78 mm., length of antenna 0.74 mm., length and width of prothorax 0.80 mm. and 0.82 mm., length and width of elytra 3.20 mm and 1.62 mm.

Holotype (sex. indet.): India, Nicobar Is., Campbell Bay, 27.x.2003, T.K. Pal & party, ex. under bark (Zoological Survey of India).

Etymology: The species name signifies its abbreviated characters which separate it from other known species of *Pseudobothrideres* Grouvelle.

Remarks: This species comes close to *Psudobothrideres velatus* Grouvelle but can be differentiated by its nearly quadrate prothorax (0.97:1.00); finer and sparser puncturation on head and near absence of puncturation on raised intervals of elytra, whereas in *velatus* prothorax is elongate (1.05:1.00) and there are minute punctures on raised intervals on elytra. Its placement in the genus *Pseudobothrideres* is tentative as the transverse impressed line on prosternal process between anterior coxae is not visible. Detailed study based on more specimens is needed to ascertain its correct generic status.

Genus ***Erotylathris*** Motschulsky

1861. *Erotylathris* Motschulsky, *Bull. Soc. Imp. Nat. Moscou*, **34**: 130 [Type-species: *Erotylathris septemcostatus* Motschulsky, by monotypy].
1885. *Antoderus* Sharp, *J. Linn. Soc. Lond.*, **19**: 126.

Distribution: Sri Lanka, Indonesia, Malaysia, Philippines, Australia, New Guinea, India (New record).

This is the first record of the genus from India

Erotylathris philippinensis Heinze

1943. *Erotylathris septemcostatus philippinensis* Heinze, *Ent. Blätter*, **39**: 122.
1989. *Erotylathris philippinensis*: Slipinski, Pope & Aldridge, *Pol. Pismo Ent.*, **59**: 137.

Distribution: India: Nicobar Is. (New record); Indonesia, Malaysia, Philippines.

New record: Material: 1 ex. (sex indet.), India, Nicobar Is., Campbell Bay, 7.x.2003, T.K. Pal & party, *ex.* under bark. This is the first record of this species from India.

Genus ***Machlotes*** Pascoe

1836. *Machlotes* Pascoe, *J. Ent.*, **2**: 36 [Type species: *Machlotes porcatus* Pascoe].

Distribution: India, Sri Lanka, Myanmar, Malaysia, Philippines, Japan, Pacific Islands, Madagascar, Africa.

Machlotes porcatus Pascoe

1836. *Machlotes porcatus* Pascoe, *J. Ent.*, **2**: 36.

Distribution: India: Tamil Nadu, Pondicherry; Malaysia.

New record: Material: 1 ex. (sex. indet.), India, Nicobar Is., Campbell Bay, 2.xii.1978, B. Nandi & party, *ex.* Papita log (under bark). This is the first record of this species from Nicobar Is.

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REFERENCES

Craighead F. C. (1920) Biology of some Coleoptera of the families Colydiidae and Bothrideridae. Proceedings of the Entomological Society of Washington, 22: 1–13.

Crowson R. A. (1955) *The Natural Classification of the Families of Coleoptera*, Nathaniel Lloyd, London, 187.

Erichson W. F. (1845) *Naturgeschichte der Insekten Deutschlands. Abt. 1. Coleoptera*, vol. 3, Lief 2. Nicolai: Berlin.

Hetschko A. (1930) Colydiidae. In: *Coleopterorum Catalogus, pars*, Junk W. and Schenkling S. (Eds). vol. 107: 1–124.

Lawrence J. F. (1980) A new genus of Indo-Australian Gempylodini with notes on the constitution of the Colydiidae (Coleoptera). Journal of the Australian Entomological Society, 19: 293–310.

Pal T. K. and Lawrence J. F. (1986) A new genus and subfamily of mycophagous Bothrideridae (Coleoptera : Cucujoidea) from the Indo-Australian region, with notes on the related families. Journal of the Australian Entomological Society, 25: 185–210.

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Scanning electron microscopic and electrophoretic analysis of the eggshell of *Gesonula punctifrons* (Orthoptera: Acrididae)

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ABSTRACT: Scanning electron microscopic analysis of the eggshell (chorion) of the grasshopper, *Gesonula punctifrons* revealed difference in its anterior and posterior regions. The anterior end showed various foldings and micropylar zone while the posterior zone was tapering and with almost no microstructure. When the chorion was solubilized and subjected to SDS-PAGE analysis, seven major protein bands were visualized. The molecular weight of these proteins ranged from 18.2 KD–83.2 KD.
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KEYWORDS: eggshell, chorion, SDS-PAGE, SEM, proteins

INTRODUCTION

During the last part of oogenesis in insect, the follicular epithelium of the ovariole deposits a hard coat over the egg surface called the eggshell or chorion (Chapman, 1998). The complexity of organization of the chorion has received attention for its importance in both taxonomic and physiological studies (Hinton, 1969). The chorions of different insects have been subjected to critical analysis by applying various instrumental methods including TEM, SEM, and electrophoretic analysis (Margaritis *et al.*, 1980). Hinton and Service (1969) extensively studied the chorion morphology of several insect orders. Furneaux *et al.* (1969) analyzed the process of development of chorion layer in *Achaeta* by using TEM method. Kawasaki *et al.* (1971) analyzed the protein component of *Gryllus* and showed that the chorion layer was composed of at least two kinds of structural proteins. Kimber (1980) made extensive TEM study of the process of choriogenesis in *Schistocerca gregaria* and elucidated the role of follicle cells in deposition of chorion layer after the termination of vitellogenesis. Apart from these, little work has been undertaken on the surface structure or protein composition of orthopteran chorions, while large amount of data have accumulated

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in case of *Drosophila* (Pascucci *et al.*, 1996) and silkworm (Powell *et al.*, 1988; Reiger *et al.*, 1982). Various kinds of structural details of the chorion layer have been brought out by modern SEM study (Ma *et al.*, 2002) and protein and nucleic acid analysis techniques (Bouts *et al.*, 2007; Konstandi *et al.*, 2006). Ganguly *et al.* (2008) described the structure of eggshell surface of two Indian short horned grasshoppers, *Hierogiyphus banian* and *Acrida exaltata* by SEM. The present communication gives a preliminary account of eggshell morphology of *Gesonula punctifrons* (Orthoptera: Acrididae) revealed by SEM study along with its protein composition analyzed by SDS-PAGE technique.

MATERIALS AND METHODS

Gesonula punctifrons were collected from paddy fields in and around Agartala city. Ripe eggs were dissected out of the ovariole in Ringer's solution and cleaned in 100 mM Tris-HCl (pH 8.1) with brush. The cleaned eggs were fixed in 2% buffered cold gluteraldehyde (0.01M phosphate buffer, pH 7.2) for two hour and dehydrated in ice-cold graded ethanol. Gold coated eggs were visualized in a Phillip's Elmiskope. For electrophoretic analysis, eggshells were ruptured and cleaned in 100 mM Tris-HCl (pH 8.1) with brush. The clean eggshells were collected in an eppendrof tube and mixed with 0.02N NaOH and 10% SDS solution containing 1 mM PMSF. This solution was heated in a boiling water bath at 100 °C to solubilize the eggshells, and used for SDS-PAGE analysis. Polyacrylamide gel electrophoresis was performed on 1.5 mm slab and at 15% gel concentration following the method of Laemmli (1970). Electrophoresis was carried out with solubilized eggshells and marker proteins at 16 mA constant current. The gel after complete run was stained overnight with Coomassie Brilliant Blue.

RESULTS AND DISCUSSION

The egg of *G. punctifrons* is cylindrical, with mean length of about 4 mm and width of 1 mm, and tapered at the posterior end. SEM studies showed that the eggshell was divided into two regions, the anterior pole and the posterior pole (Figs. 1, 2). Throughout the surface of the eggshell numerous micro sculptures and folds were present. On the basis of SEM picture, in the anterior pole region the micropylar zone (MZ) was visualized, with a groove at the apex. In the posterior part the organization of the micro sculpture was different and six vertical ridges (VR) were seen to divide the whole egg circumference, and between these ridges 6–7 longitudinal foldings were present which were connected by minor transverse foldings. The vertical ridges of the chorion layer became indistinct at the end and joined with the end surface (posterior pole) of the egg, which took a flat hexagonal shape (HPP). These vertical ridges are 26.66 μm thick and the distance between the two ridges is 480 μm. At the end part of the posterior pole the number of foldings between the ridges became diminished, indistinct and fused with the end part. The distance between the two foldings at the end part is 106–133 μm. In the anterior pole no ridges were present

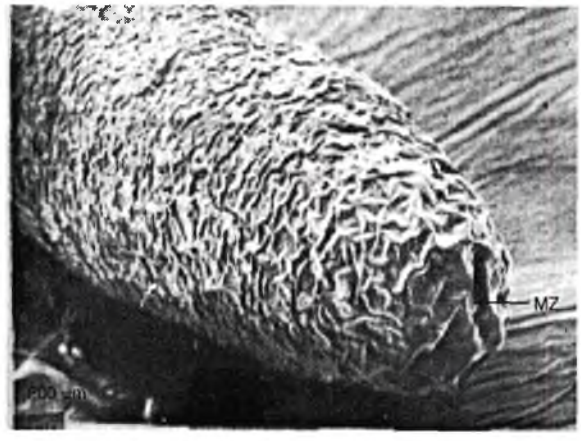

FIGURE 1. Scanning electron microscopic view of the micropylar region (MZ) of the egg of *Gesonula punctifrons*

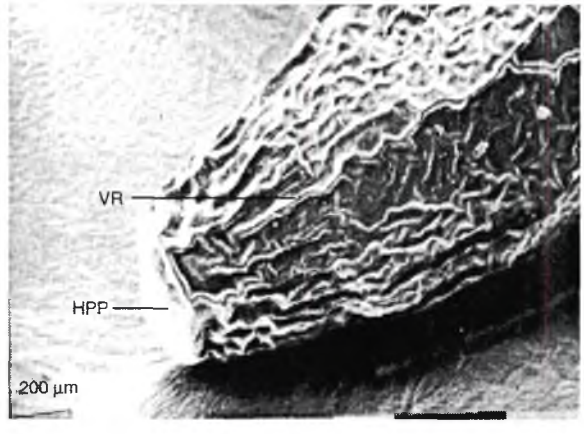

FIGURE 2. Scanning electron microscopic view of the posterior region (HPP) of the egg of *Gesonula punctifrons*, showing the vertical ridges (VR)

but the surface was uniformly distributed with numerous folds forming star shaped protuberances and parallel shaped structures. The folds were 13.33 μm thick and the distance between two folds was 40–80 μm. The micropylar zone was circular in appearance and groove was prominent having 3–4 folds which meet in the central part. The distance between two folds was 106–160 μm. The difference in the morphology of the anterior and posterior pole indicates that the chorion layer was deposited asymmetrically in the anterior and posterior poles of the egg. Similar asymmetry of anterior posterior structure has been observed in *Drosophila* (Margaritas *et al.*,

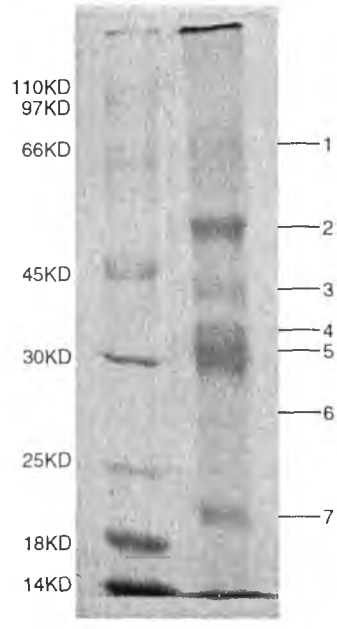

FIGURE 3. Photograph of the SDS PAGE electrophorogram of solubilised chorion proteins of *Gesonula punctifrons*

1976), *Aedes mediovittatus* (Linley and Clark, 1989), *Ae. albopictus, Ae. aegypti, Ae. bagamensis* and *Ae. triseriatus* Linley, 1989a,b).

When the solubilized chorion was subjected to SDS-PAGE analysis altogether seven polypeptide bands became apparent (Fig. 3). For analysis of the molecular weight of the resolved polypeptides parallel run of molecular weight marker proteins were given (β-galactosidase (1,10,000), phosphorylase (97,000), bovine serum albumin (66,000), ovalbumin (45,000), carbonic anhydrase (30,000), BamH1 (25,000), lactoglobulin (18,000) and lysozyme (14,000)). From plotting of logarithm of molecular weight of the standard protein and their Rm values a linear standard curve was prepared. On the basis of that curve the molecular weights of the chorion polypeptides of *G. punctifrons* were determined as 83.2 KD, 57.5 KD, 45.7 KD, 39 KD, 33.1 KD, 23 KD and 18.2 KD. It may be concluded that at least seven polypeptides participate in the formation of eggshell of *G. punctifrons*. However, no definite comment could be made whether other polypeptides were present or not. This is the first study on chorion proteins of grasshopper. At least two protein components are present in the eggshell of *Gryllus* (Orthoptera) (Kawasaki *et al.*, 1971) while 100 or more have been noted in silkworm (Lepidoptera) (Reiger *et al.*, 1982). The present report shows the presence of relatively high number of polypeptides in the eggshell of the grasshopper, *G. punctifrons* along with its structural asymmetry.

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REFERENCES

Bouts M. D. D., Melo A. C. A., Andrade A. L. H., Silva-Neto M. A. C., Paiva-Silva G. O., Sorgine M. H. F., Gomes L. S. C., Coelho H. S., Furtado A. P., Aguiar E. C. M., Medeiros L. N., Kurtenbach E., Rozental S., Cunha-E- Silva N. L., Souza W. and Masuda H. (2007) Biochemical properties of the major proteins from *Rhodnius prolixus* eggshell. Insect Biochemistry and Molecular Biology, 37: 1207–1221.

Chapman R. F. (1998) *The Insects: Reproductive System: Female*, Cambridge University Press, Cambridge, 298–321.

Furneaux P. J. S., James C. S. and Potter S. A. (1969) The eggshell of the house cricket (*Acheta domesticus*): an electron microscopic study. Journal of Cell Science, 5: 227–249.

Ganguly A., Malakar C., Anand H., Das S., Das A. and Haldar P. (2008) Scanning electron microscopy of egg-surface sculpturing of two common Indian short-horn grasshoppers (Orthoptera, Acrididae). Journal of Orthoptera Research, 17: 97–100.

Hinton H. E. (1969) Insect Eggshells. Scientific American, 223(2): 84–91.

Hinton H. E. and Service M. W. (1969) *The Surface Structure of Aedine Eggs as Seen with the Scanning Electron Microscope*. Annals of Tropical Medicine and Parasitology, 409–411.

Kawasaki H., Kato H. and Suzuki M. (1971) Structural proteins in the Egg-shell of the oriental Garden Cricket. Gryllus mitratus Biochemical Journal, 125: 495–505.

Kimber S. J. (1980) The Secretion of thr eggshell of *Schistocerca gregaria*: Ultrastructure of the follicle cells during the termination of vitellogenesis and eggshell section. Journal of Cell Science, 46: 455–477.

Konstandi O. A., Papassideri I. S., Stravopodis D. J., Antonelou M. H., Kenoutis C. A., Stefanidou D. C., Margaritis L. H. and Konstandi (2006) The dual role of chorion peroxidase in *Bactrocera oleae* chorion assembly. International Journal of Developmental Biology, 50: 543–552.

Laemmli U. K. (1970) Cleavage of structural proteins during the assembly of the head of bacteriophage T4. Nature, 227: 680–685.

Linley J. R. (1989a) Scanning Electron Microscopy of the egg of *Aedes (Protomacleaya) triseriatus* (Diptera: Culicidae). Journal of Medical Entomology, 26(5): 474–478.

Linley J. R. (1989b) Comparative fine structure of the eggs of *Aedes albopictus*, *Ae. aegypti*, and *Ae. Bahamensis* (Diptera: Culicidae). Journal of Medical Entomology, 26(6): 510–521.

Linley J. R. and Clark G. G. (1989) Egg of *Aedes (Gymnometopa) mediovittatus* (Diptera: Culicidae). Journal of Medical Entomology, 26(4): 252–255.

Ma P. W. K., Baired S. and Ramaswamy S. B. (2002) Morphology and formation of the eggshell in the tarnished plant bug, *Lygus lineloaris* (Palisot de Beauvois) (Hemiptera:Miridae). Arthropod Structure & Development, 31: 131–146.

Margaritas L. H., Petri W. H. and Kafatos F. C. (1976) Three dimensional structure of the endochorion in wild type *Drosophila melanogaster*. The Journal of Experimental Zoology, 198(3): 403–408.

Margaritis L. H., Kafatos F. C. and Petri W. (1980) The eggshell of *Drosophila melanogaster*. Journal of Cell Science, 43: 1–35.

Pascucci T., Perrino J., Mahowald A. P. and Waring G. L. (1996) Eggshell assembly in *Drosophila*: Processing and localization of vitelline membrane and chorion protein. Developmental Biology: 590–598.

Powell J. R., Hollander A. L. and Fuchs M. S. (1988) Development of the *Aedes aegypti* Chorion: Proteins and Ultrastructure. International journal of Invertebrate. Reproduction and Development. 13: 39–54.

Reiger J. C., Mazur G. D., Kafatos F. C. and Paul M. (1982) Morphogenesis of Silkmoth chorion: initial framework formation and its relation to synthesis of specific proteins. Developmental Biology, 160: 236–245.

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Occurrence of *Menacanthus eurysternus* on Indian Bank Myna and Starlings

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ABSTRACT: Common Myna (*Acridotheres tristis* Linnaeus), Bank Myna (*Acridotheres ginginianus* Latham), Brahminy Starling (*Sturnus pagodarum* Gmelin) and common Starling (*Sturnus vulgaris* Linnaeus) were examined for the presence of phthirapteran ectoparasites. Two amblyceran species (*Menacanthus eurysternus* and *Myrsidea invadens*) and five ischnoceran species (*Brueelia ginginianus*, *B. chayanh*, *B. nebulosa*, *Sturnidoecus bannoo* and *S. affinis*) were recorded. The occurrence of *Menacanthus eurysternus* on Bank Myna, Brahminy Starling and common Starling has been noted for the first time in India. © 2009 Association for Advancement of Entomology

KEYWORDS: Phthiraptera, Mallophaga, chewing lice, *Menacanthus eurysternus*

Lakshminarayana (1979) has given a synoptic list of phthirapteran ectoparasites infesting Asian birds. Price *et al.* (2003) have provided a comprehensive checklist of Phthiraptera pararsitizing different avian hosts. Ecological studies on avian lice parasitizing Indian common Myna, *Acridotheres tristis* have been made by Chandra *et al.* (1990) and Saxena *et al.* (2007). Literature revealed that taxonomic studies on pththirapteran fauna of common Indian Myna and Starling deserved further investigations. Present report deals with Phthirapteran fauna of Indian common Myna, Bank Myna, common Starling and Brahminy Starling.

The aforesaid birds (3 each) were netted alive in the district Rampur (U.P.). After tying the legs, each bird was thoroughly searched for the presence of lice by visual examination. Infested birds were then deloused by fumigation method used by Saxena *et al.* (2007). Head and body feathers were further examined to remove the remaining lice. The lice so obtained were subjected to maceration (10% KOH), dehydration (ethanol series), clearing (clove oil) and mounting (Canada Balsam). Deloused birds were released in wild to lead healthier life.

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As many as nine phthirapteran species belonging to five genera eg., *Brueelia* (*B. chayanah, B. iliaci*), *Menacanthus* (*M. spiniferus, M. tristisi*) *Myrsidea* (*M. chilchil*), *Sturnidoecus* (*S. affinis, S. sturni, S. avinus*) and *Turturicola* (*T. salimalii*) have been listed to occur on Indian common Myna by Lakshminarayana (1979). However, Price *et al.* (2003) recognized only six phthirapteran species from aforesaid birds (*B. chayanh, B. fuscopleura, Menacanthus eurysternus, Myrsidea invadens, S. bannoo* and *S. fragilis*); the other species were referred as contaminants/synonyms. During present studies five phthirapteran species (*B. chayanh, S. bannoo, S. affinis, M. eurysternus* and *Myrsidea invadens*) were recorded from common Myna in the district Rampur, India. Chandra *et al.* (1989, 1990) and Saxena *et al.* (2007) recovered four phthirapteran species (*Menacanthus eurysternus, Brueelia* sp., *Sturnidoecus* sp. and *Myrsidea* sp.) from Indian Common Myna. The present report is in confirmation to Ansari (1955).

Four phthirapteran species (*B. ginginianus, B. iliaci, S. bannoo* and *S. sturni*) reportedly infest the Indian Bank Myna (Lakshminarayana, 1979). Price *et al.* (2003) have recognized the presence of only three species (*B. ginginianus, M. eurysternus* and *S. bannoo*). During present studies the presence *M. eurysternus* was also noted on Indian Bank Myna along with *S. bannoo* and *B. ginginianus.*

Only two phthirapteran species (*B. pagodarum* and *S. sturni*) reportedly occur on Brahminy Starling (Lakshminarayana, 1979). Price *et al.* (2003) recognized the presence of *B. pagodarum* and *M. eurysternus* on Brahminy Starling. Thus, the presence of *M. eurysternus* (only phthirapteran species recovered) on the aforesaid host has been noted for the first time in India.

Three phthirapteran species (*S. sturni, Spironirmus chitlatllyar* = *B. nebulosa* and *Myrsidea cucularis*) reportedly infest the common starling (Lakshminarayana, 1979). Price *et al.* (2003) recognized five species (*B. nebulosa, M. eurysternus, Myrsidea cucularis, Ricinus elongatus* and *S. sturni*) from aforesaid bird. During present investigations the presence of only two phthirapterans (*M. eurysternus* and *B. nebulosa*) was recorded from common starlings. The occurrence of *M. eurysternus* was also recorded first time from aforesaid host in India. It may be noted that *M. eurysternus* is a haematophgous amblyceran (Agarwal *et al.*, 1983). The haematophagous lice do not only affect the health of infested birds (due to irritation/itching caused by the claws present on the legs and the mandibles) but also often act as reservoir and transmitter of infectious diseases (Saxena *et al.*, 1985) and are capable of acting as intermediate host of filarial worms (Price and Graham, 1997). Lesions made by the lice often act as potential site for the entry of other pathogens.

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REFERENCES

Agarwal G. P., Saxena A. K. and Chandra S. (1983) Haematopahgous behaviour of *Menacanthus eurysterrnus* (Mallopthaga, Amblycera). Angewandte Parasitologie, 24: 55–59.

Chandra S., Agarwal G. P. and Saxena A. K. (1989) Distribution of Mallophaga on the body of *Acridotheres tristis* (Aves). Angewandte Parasitologie, 30(1): 39–42.

Chandra S., Agarwal G. P., Singh S. P. N. and Saxena A. K. (1990) Seasonal changes in a population of *Menacanthus eurysternus* (Mallophaga, Amblycera) on the common myna *Acridotheres tristis*. International Journal for Parasitology, 20(8): 1063–1065.

Lakshminarayana K. V. (1979) A synoptic list of Mallophaga Sens. Lat. (Phthiraptera:Insecta) from India and adjacent countries together with host and regional indices. Records of Zoological Survey of India, 75: 39–201.

Price M. A. and Graham O. H. (1997) Chewing and sucking lice as parasites of mammals and birds.U. S. Department of Agriculture. In: *Technical Bulletin No, 1849*, p. 309.

Price R. D., Hellenthal R. A., Palma R. L., Johnson K. P. and Clayton D. H. (2003) The chewing lice: world checklist and biological overview. Illinois natural history survey special publication 24, *x*+, p. 501.

Saxena A. K., Agarwal G. P., Chandra S. and Singh O. P. (1985) Pathogenic involvement of Mallophaga. Zeitschrift for Angewandte Entomologie, 99: 294–301.

Saxena A. K., Kumar S., Gupta N., Mitra J. D., Ali S. A. and Srivastava R. (2007) Distribution pattern of phthirapterans infesting certain common Indian birds. Journal of Parasitology, 93(4): 957–958.

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Population dynamics of Phthiraptera on Indian Bank Myna, *Acridotheres ginginianus*

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ABSTRACT: Population characteristics of three phthirapteran species (*Brueelia ginginianus, Sturnidoecus bannoo* and *Menacanthus eurysternus*) on 147 Bank Myna (*Acridotheres ginginaius*) were recorded during 2007, in the district Bijnore, U.P., India. Frequency distribution patterns of all the species were aggregated but failed to correspond the negative binomial model. © 2009 Association for Advancement of Entomology

KEYWORDS: Phthiraptera, frequency distribution pattern, biting lice, lice population

Population characteristics of Phthiraptera on selected Indian birds have been recorded from time to time (Trivedi *et al.*, 1992; Saxena *et al.*, 1995; Khan *et al.*, 2008; Singh *et al.*, 1998). Information about the population parameters of phthirapterans parasitizing the common Myna, *Acridotheres tristis* has been provided by Chandra *et al.* (1989, 1990)) and Saxena *et al.* (2007). Similar studies on the Bank Myna, *Acridotheres ginginianus* deserved investigation. Present report furnishes information on the prevalence, intensity of infestation, frequency distribution patterns and the population composition of three phthirapteran ectoparasites (*Brueelia ginginianus* Ansari, *Sturnidoecus bannoo* Ansari, and *Menacanthus eurysternus* Burmeister) infesting Bank Myna, in the district Bijnore, U. P., India.

At least 12 birds were netted alive each month in the year 2007, in the district of Bijnore. After tying the legs, each bird was subjected to visual examination. Infested birds were deloused by fumigation (Gupta *et al.*, 2007). Efficacy of different delousing methods has been discussed by Clayton and Drown (2001). Deloused birds were further examined to remove the remaining lice. The louse load obtained from each infested bird was placed in 70% alcohol and separated species wise, sex wise and stage wise. Deloused birds were released in wild to lead more healthy life. Population characteristics (prevalences, mean intensities, sample mean abundances, variance to

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TABLE 1. Popualtion dynamics of three phthirapteran species on Bank Myna (*Acridotheres ginginianus*) during 2007–2008, in the district Bijnore, U. P., India

Parameter	*Brueelia ginginianus*	*Sturnidoecus affinis*	*Menacanthus eurysternus*
Sample size	147	147	147
Prevalence (%)	48.3	38.8	30.6
Mean Intensity	16.6	8.2	6.8
Sample mean abundance	8.0	3.2	2.1
Range of infestation	1–53	1–23	1–17
Variance to mean ratio	21.1	8.3	7.54
Pattern of distribution curve	Aggregated	Aggregated	Aggregated
Index of discrepancy (D)	0.738	0.742	0.797
Exponent of negative binomial (k)	0.19	0.19	0.14
Whether the negative binomial "good fit"	No	No	No
Male, female ratio	1:1.1	1:1	1:1
Adult, nymph ratio	1:0.8	1:0.9	1:1.1
Ratio of I, II and III instar nymphs	1:1:1.1	1:1.1:1.2	1:1.1:2

mean ratios, exponent of negative binomial (k) and indices of discrepancy (D) were computed with software offered by Rozsa *et al.* (2000). The goodness of fit between the observed and expected frequencies (negative binomial) was determined by χ^2.

Fifty six percent of birds examined were found infested with phthirapteran ectoparasites (n = 147). Maximum number of lice collected from single bird was 65 (mean intensity—33.5; sample mean abundance—13.3). More than half (55.4%) of the infested birds carried two species. Simultaneous infestation by all the three lice was encountered on 26.5% of infested birds. Rest of the infested birds (18.1%) were parasitized by single species. The prevalences, mean intensities and sample mean abundances of each species on the Bank Myna, have been indicated in Table 1. The ischnoceran louse, *B. ginginianus* was the most prevalent species, followed by *S. bannoo* (in terms of prevalence, intensity of infestation and the range of the infestation).

Frequency distribution patterns of all the three lice were aggregated as the variance to mean ratio exceeded unity. However, the patterns of frequency distribution did not conform to negative binomial model, as the expected frequencies differed significantly from the observed frequencies. Sex ratio was female biased in case of *B. ginginianus*. Adult population dominated over nymphal population in case of ischnoceran lice (*B. ginginianus* and *S. bannoo*) while nymphal population had an edge over adults in case of amblyceran lice (*M. eurysternus*).

Studies reveal that the prevalences, intensities of infestation and the ranges of infestation of three phthirapteran species were not alarming. Furthermore, the prevalence and intensity of infestation of the amblyceran louse, ***M. eurysternus*** (haematophagous) were lowest.

Phthirapteran ectoparasites reportedly exhibit clumped distribution (aggregated) on host birds (Rekasi *et al.*, 1997). Latter have found that the distribution pattern of 21 (out of 27) species occurring on thirteen birds conformed to negative binomial model. However, Saxena *et al.* (2007), Gupta *et al.* (2007) and Beg *et al.* (2008) noted that distribution pattern of only one louse (out of 17 species) occurring on six avian hosts conformed to negative binomial model. During present studies, the negative binomial was not found to be a good fit in case of three Bank Myna lice. Reasons responsible for skewed sex ratio and unequal adult nymph ratio have been indicated elsewhere (Marshall, 1981; Gupta *et al.*, 2007).

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REFERENCES

Beg S., Gupta N., Kumar S., Khan V., Bhatnagar S. and Saxena A.K. (2008) Occurrence of Phthiraptera on the house crow, *Corvus splendens* (Phthiraptera: Corride). Entomon, 33(1): 75–78.

Chandra S., Agarwal G. P. and Saxena A. K. (1989) Distribution of Mallophaga on the body of *Acridotheres tristis* (Aves). Angewandte Parasitologie, 30: 39–42.

Chandra S., Agarwal G. P., Singh S. P. N. and Saxena A. K. (1990) Seasonal changes in a poppulation on *Menacanthus eurysternus* (Mallophaga: Amblycera) on the common Myna, *Acridotheres tristis*. International Journal of Parasitol, 20(8): 1063–1065.

Clayton D. H. and Drown D. N. (2001) Critical evaluation of five methods for quantifying chewing lice (Insecta: Phthiraptera). Journal of Parasitology, 87: 1291–1300.

Gupta N., Kumar S. and Saxena A. K. (2007) Prevalence and population structure of lice (Phthiraptera) on the Indian Red Avadavat. Zoological Science, 24: 381–383.

Khan V., Kumar S., Gupta N., Ahmad A. and Saxena A. K. (2008) Prevalence of phthirapteran ectoparasites on selected poultry in the district, Rampur (U.P.). Indian Veterinary Journal, Accepted

Marshall A. G. (1981) *The Ecology of Ectoparasitic Insects*, Academic Press, London.

Rekasi J., Rozsa L. and Kiss B. J. (1997) Patterns in the distribution of avian lice (Phthiraptera: Amblycera, Ischnocera). Journal of Avian Biology, 28: 150–156.

Rozsa L., Reiczigel J. and Majoros G. (2000) Quantifying parasites in sample of hosts. Journal of Parasitology, 86: 228–232.

Saxena A. K., Kumar A., Surman and Singh S. K. (1995) Prevalence of *Menopon gallinae* Linne. (Phthiraptera : Amblycera) on poultry birds of Garhwal. Journal of Parasitic Diseases, 19(1): 69–72.

Saxena A. K., Kumar S., Gupta N., Mitra J. D., Ali S. A. and Srivastava R. (2007) Distribution pattern of phtirapterans infesting certain common Indian birds. Journal of Parasitology, 93(4): 957–958.

Singh S. K., Surman, Kumar A. and Saxena A. K. (1998) Population composition of four phthirapterans infesting blue rock pigeon (*Columba livia*). Journal of Parasitic Diseases, 22(2): 144–148.

Trivedi M. C., Saxena A. K. and Rawat B. S. (1992) Incidence of Mallophaga on poultry in dehradun (India). Angewandte Parasitologie, 33: 69–78.

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Determination of larval instars in mulberry leaf roller, *Diaphania pulverulentalis* (Hampson) (Lepiodoptera: Pyralidae)

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ABSTRACT: There has been some confusion on the number of larval instars undergone by the mulberry leaf roller, *Diaphania pulverulentalis* (Hampson) as earlier workers had reported three to five larval instars. In the present study, by measurement of head capsule width and application of Dyar's rule it is shown that *D. pulverulentalis* has five larval instars. © 2009 Association for Advancement of Entomology

The mulberry leaf-roller, *Diaphania pulverulentalis* (Hampson) (Lepiodoptera: Pyralidae) causes extensive damage to mulberry, the sole host plant of the silkworm, *Bombyx mori* L. The pest is distributed in China, Japan, India, Vietnam, Sri Lanka and Myanmar (Manjunath *et al.*, 2005). The larval stage of the pest lasts 13–19 days. However, the number of instars that the insect completes during this period has not yet been clearly established. The number of larval instars reported are five (Seol *et al.*, 1986), four to five (Rangaswami *et al.*, 1976), four (Sengupta *et al.*, 1990) or three (Rajdurai *et al.*, 1999). In this context, a study involving head capsule width measurement was conducted to ascertain the number of instars of *D. pulverulentalis*.

For the present study 160 larvae of *D. pulverulentalis* at different stages of growth were collected from the mulberry gardens in Chintamani Taluk and preserved in 70 per cent alcohol. The head capsule width of all the larvae was measured using Zeiss stereoscope microscope equipped with calibrated eyepiece. The data were used to construct a frequency table to assign individual insect into different class intervals/instars (Table 1) and analyzed statistically. Further, Dyar's rule (Dyar, 1890), which states that the width of head capsule of larva in successive instars grows in geometric progression, was employed to estimate the head capsule width. The goodness of fit ($\chi 2$) of the estimates was tested.

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TABLE 1. Statistical classification of larvae of *D. pulverulentalis* into different larval instars based on head capsule width

Class intervals for head capsule width (mm)	Instar	Observed mean head capsule width (mm)	Standard deviation	Variance	Rate of increase in head capsule width	Estimated head capsule width as per Dyar (mm)	Sample size (n)
0.17–0.20 0.21–0.24 0.25–0.28	I	0.211	0.023	0.00053	–	0.211	29
0.37–0.40 0.41–0.44	II	0.405	0.022	0.00050	1.919	0.322	32
0.57–0.60 0.61–0.64 0.65–0.68	III	0.611	0.029	0.00086	1.509	0.619	31
0.77–0.80 0.81–0.84 0.85–0.88	IV	0.808	0.024	0.00056	1.322	0.933	36
1.01–1.04 1.05–1.08 1.09–1.12 1.13–1.16 1.17–1.20	V	1.099	0.033	0.00108	1.360	1.234	32

The results indicated that the 160 larvae fell into five classes, which could be designated as instars (Table 1). This was further confirmed by the fact that plotting these individuals under different class intervals for head capsule width on a graph provided five discrete peaks (Fig. 1), indicating the individuals of same instar falling around each peak.

The mean value of head capsule width of instars I, II, III, IV and V of *D. pulverulentalis* was found to be 0.211, 0.405, 0.611, 0.808 and 1.099 mm, respectively. The standard deviation, variance and sample size are presented in Table 1. The rate of increase in head capsule width over previous instar was estimated and mean rate of increase over the entire larval duration was calculated to be 1.528. Using this ratio the expected head capsule width of instars I, II, III, IV and V was estimated using the formula, Head capsule width of the instar = Observed head capsule width in the previous instar $\times 1.528$, and it was found to be 0.322, 0.619, 0.933 and 1.234 mm, respectively (Table 1). These estimates were found to satisfy the test of goodness of fit ($\chi 2 = 0.054$ at 4 degrees of freedom).

The head capsule size remains the same for a particular instar of the larva and hence, its width can be used as an index to identify the specific instar (Dyar, 1890). Similar studies on the rate of increase of head capsule width in the pumpkin caterpillar, *Diaphania indica* (Saunders) has revealed five instars with an average rate of increase

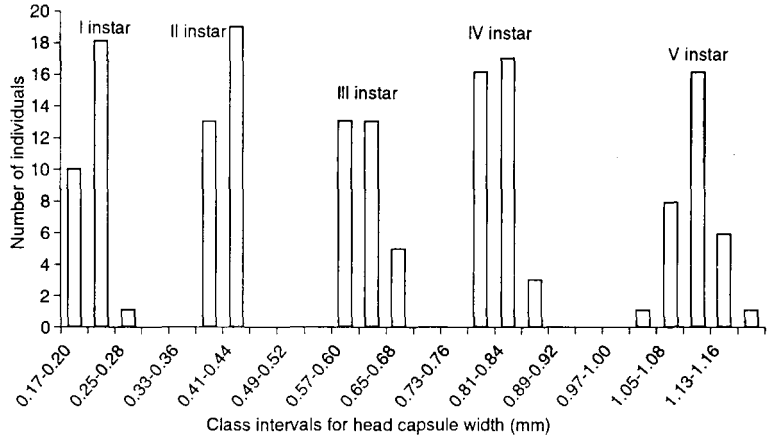

FIGURE 1. Frequency distribution of larvae of *D. pulverulentalis* with respect to head capsule width.

of 1.56 times (Peter and David, 1991) which is close to 1.528 estimated for *D. pulverulentalis* in this study. From these results it is obvious that there are five larval instars in *D. pulverulentalis*, thus ending the uncertainty. *D. pulverulentalis* larvae may be assigned to a particular instar by measuring their head capsule width.

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REFERENCES

Dyar H. C. (1890) The number of moults of lepidopterous larvae. Psyche, 5: 420–422.

Manjunath Gowda, Narayanaswamy K. C. and Ninge Gowda K. N. (2005) Status of leaf roller pests of mulberry. Journal of Ecobiology, 17(3): 201–216.

Peter C. and David B. V. (1991) Head capsule width measurement for instar determination in *Diaphania indica* (Saunders) (Lepiodoptera: Pyralidae). Journal of Insect Science, 4(2): 153–154.

Rajdurai S., Manjunath D., Katiyar R. L., Prasad K. S., Sen A. K., Shekhar M. A., Ahsan M. M. and Datta R. K. (1999) Leaf roller - a serious pest of mulberry. Indian Silk, 37(12): 9–11.

Rangaswami G., Narasimhanna M. N., Kasivishwanathan K., Sastry C. R. and Jolly M. S. (1976) *Sericulture Manual – I, Mulberry Cultivation*. FAO, p. 50.

Sengupta K., Kumar P., Baig M. and Govindaiah (1990) *Handbook of Pests and Diseases Control of Mulberry and Silkworm*. ESCAP, p. 88.

Seol K. Y., Honda H. and Matsumoto K. (1986) Artificial diets for mass rearing of the lesser mulberry pyralid, *Glyphodes pyloalis* (Walker) (Lepidoptera: Pyralidae). Applied Entomology and Zoology, 21(1): 109–113.

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Effect of precocene on morphogenesis in housefly, *Musca domestica* Linn.

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ABSTRACT: Administration of precocene II to last instar larvae of housefly, *Musca domestica* significantly reduced its life span, leading to precocious pupariation, formation of abnormal puparia, adultoids suffering from ecdysial stasis and emergence of adult flies with wing deformities. Precocene induced effects were due to deficiency of juvenile hormone as exogenous application of JH to treated larvae abolished the effects. © 2009 Association for Advancement of Entomology

KEYWORDS: precocene II, JH, morphogenesis, *Musca domestica*

Proallatocidins or precocenes first isolated from the plant *Ageratum houstonianum* selectively destroy the corpora allata of insects leading to symptoms of juvenile hormone deficiency (Bowers *et al.*, 1976; Feyereisen *et al.*, 1981). The activity of precocenes is mostly confined to hemimetabolous insects where these compounds produce precocious metamorphosis, allatocidal effects and a variety of morphogenetic effects (Hardie *et al.*, 1995, 1996; Gao and Hardie, 1996). The holometabolous insects are considered less susceptible to precocenes (Ohta *et al.*, 1977) because of detoxification of these compounds in tissues like fat body (Soderlund *et al.*, 1980).

So far only a few studies have been made on the effect of precocenes in cyclorrhaphous Diptera, a group in which hormonal control of moulting and metamorphosis is remarkably different from that of other insects. The effects comprised suppression of imaginal differentiation and interference with metamorphosis in *Sarcophaga ruficornis* (Srivastava and Kumar, 1996; Khan and Kumar, 2005) and inhibition of oocyte development in *Drosophila melanogaster* (Wilson *et al.*, 1983), *Phormia regina* (Yin *et al.*, 1989) and *S. ruficornis* (Kumar and Khan, 2004). The present paper describes the effect of precocene administration to last instar larvae of *Musca domestica*.

Cultures of housefly, *Musca domestica*, were maintained in the laboratory at 27 ± 1 °C. Adult flies were fed on honey solution. Fresh slices of goat's kidney were used for egg laying and for feeding the larvae.

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Precocene II (6,7-dimethoxy-2,2-dimethylchromene) and juvenile hormone III obtained from Sigma Chemical Co., USA., were dissolved in acetone to obtain different concentrations of the compounds in 1 μl acetone. In separate sets of experiments, 1 and 2 day old third instar larvae were treated with 100 and 200 μg of precocene II applied on the posterior abdominal region with the help of a Hamilton syringe. One-day old third instar larvae were also treated with precocene II (200 μg) and JH (10 μg). Control larvae of similar age groups were treated with 1 μl of solvent only. Further development of both control and treated larvae were observed daily.

Application of precocene II to last instar larvae of *M. domestica* resulted in mortality of 10 to 20% of larvae (Table 1). Death occurred within a few hours of treatment or in the pupal or adult moult. Precocene treatment also significantly reduced the life span of the surviving larvae as compared to that of control leading to precocious pupariation and development of abnormal puparia. The formation of abnormal puparia was positively correlated with the dose administered. The abnormal puparia suffered from a number of morphological abnormalities such as failure of retraction of anterior larval segments and inhibition of longitudinal body contraction and cuticular shrinkage leading to formation of elongated puparia with coarse body surface. In most severe cases, extremely deformed larva like puparia were also formed. In all such cases the pupal pigmentation was not uniform and consisted of blending of dark brown and black pupal pigmentation. The developing insects within the abnormal puparia were non-viable.

At a dose of 100 μg precocene II, normal adult flies emerged from normal puparia but at a higher dose of 200 μg the flies had crumpled wings and survived only for a short period of 4–5 h after emergence. The percentage of emerging flies decreased with the increase in dose.

The normal puparia from which adult flies did not emerge of their own were opened after the emergence of controls. They were found to contain adultoids. The percentage of formation of adultoids increased with the increase in dose. These adultoids were considerably smaller in size as compared to normal adult flies and suffered from a number of morphological abnormalities such as deformed head, reduced antennae, mouth parts in the form of a protuberance, cylindrical or crumpled wings and undeveloped genitalia. Fragments of pupal exuviae were found attached to different parts of the body.

Administration of JH to precocene treated larvae removes the effect of precocene restoring the normal life span of last instar larvae (Table 1). This shows that the acceleration in pupariation of precocene administered larvae is due to deficiency of juvenile hormone. The effect of precocene is antagonistic to that of JH in *Sarcophaga bullata* where JH treated last instar larvae survived for 14 days without undergoing pupariation (Srivastava and Gilbert, 1969). Puparium formation in Dipteran flies is a complicated phenomenon involving several processes such as retraction of anterior larval segments, longitudinal body contraction leading to shortening of body, cuticular shrinkage responsible for smoothening of body surface and sclerotisation or tanning of cuticle (Zdarek and Fraenkel, 1972). All the events associated with puparium

TABLE 1. Effect of Precocene II and JH on the development of last instar larvae of *M. domestica*

Treatment	Mortality (%)	Days required for pupariation (Mean ± SE)	Abnormal puparia (%)	Normal puparia	
				Unemerged adultoids (%)	Adult flies emerged (%)
One day old larvae					
Precocene II 100 μg ($n = 40$)	17	1.72 ± 0.9*	9	17	57
Precocene II 200 μg ($n = 40$)	10	1.38 ± 0.10**	10	28	52
Control 1 ($n = 20$)	0	2 ± 0	0	0	100
Two day old larvae					
Precocene II 100 μg ($n = 50$)	20	1 ± 0**	10	40	30
Precocene II 200 μg ($n = 50$)	10	1 ± 0**	15	50	25
Control 2 ($n = 20$)	0	1.8 ± 0.09	0	0	100
One day old larvae					
Precocene II 200 μg+ JH 10 μg ($n = 10$)	2	2 ± 0	0	0	98

$*p < 0.01$; $**p < 0.001$ (t test)

formation are adversely affected by precocene administration which is reversible by JH application.

Precocenes are allatocidal compounds causing destruction of corpora allata and thereby producing symptoms of juvenile hormone deficiency (Pener, 2002). Precocious metamorphosis in *Rhodnius prolixus* (Azambuja and Garcia, 1991) or moulting disturbances and development of adultoids in cotton boll worm, *Earias vitella* (Khan and Kumar, 2003) have been reported due to deficiency of juvenile hormone in precocene treated insects. Contrary to this Garcia *et al.* (1988) observed inhibition of ecdysteroid synthesis as a result of ethoxyprecocene II treatment and attributed it to the direct effect of precocene on the prothoracic glands. The various morphogenetic effects of precocene in *M. domestica* are certainly due to decreased level of intrinsic JH in treated insects as evident by the fact that the exogenous application of JH not only abolishes the effect of precocene but also restores normal metamorphosis and it does not appear to be a direct effect of precocene on the prothoracic glands. Moreover, the adultoids produced as a consequence of precocene administration were unable to free themselves from pupal exuviae and this demonstrates the decreased activity of eclosion hormone which is responsible for freeing the adult body from pupal cuticle (Novak, 1975).

REFERENCES

Azambuja P. D. and Garcia E. S. (1991) Effects of proallatotoxins (precocenes) on the development and reproduction of *Rhodnius prolixus*. Memorias do Instituto Oswaldo Cruz (Brazil), 86: 113–115.

Bowers W. S., Ohta T., Cleere J. S. and Marsella P. A. (1976) Discovery of insect anti-juvenile hormones in plants. Science, 193: 542–547.

Feyereisen R., Johnson G., Koener J., Stay B. and Tobe S. S. (1981) Precocenes as pro-allatocidins in adult female *Diploptera punctata*: a functional and ultrastructural study. Journal of Insect Physiology, 27: 855–868.

Gao N. and Hardie J. (1996) Pre-and post-natal effects of precocenes on aphid morphogenesis and differential rescue. Archives of Insect Biochemistry and Physiology, 32: 503–510.

Garcia E. S., Azambuja P. D., Feder D. and Bowers W. S. (1988) Inhibition of ecdysteroid production in nymphs of *Rhodnius prolixus* treated with ethoxyprecocene II. Archives of Insect Biochemistry and Physiology, 8: 127–134.

Hardie J., Gao N., Timar T., Sebok P. and Honda K. (1996) Precocene derivatives and aphid morphogenesis. Archives of Insect Biochemistry and Physiology, 32: 493–501.

Hardie J., Honda K., Timar T. and Varjas L. (1995) The effects of 2,2-dimethylchromene derivatives on wing determination and metamorphosis in the pea aphid, *Acyrthosiphon pisum*. Archives of Insect Biochemistry and Physiology, 30: 25–40.

Khan I. A. and Kumar K. (2003) Heterochrony in Cotton bollworm, *Earias vitella* (Fb) following ethoxyprecocene administration. Indian Journal of Experimental Biology, 41: 328–335.

Khan I. A. and Kumar K. (2005) Effect of precocene II on imaginal differentiation in flesh fly, *Sarcophaga ruficornis* F. (Diptera: Sarcophagidae). Entomon, 30: 187–191.

Kumar K. and Khan I. A. (2004) Effect of precocene on development of ovarian follicles in flesh fly, *Sarcophaga ruficornis* F. Indian Journal of Experimental Biology, 42: 74–80.

Novak V. J. A. (1975) *Insect Hormones*, Chapman and Hall, London, 365–366.

Ohta T., Kuhr R.J. and Bowers W.S. (1977) Radio synthesis and metabolism of the insect anti-juvenile hormone, precocene II. Journal of Agricultural and Food Chemistry, 25: 478–481.

Pener M. P. (2002) *Encyclopedia of Pest Management*, Pimentel David (Ed). Cornell University, New York, USA, 398–401.

Soderlund D. M., Messeguer A. and Bowers W. S. (1980) Precocene II metabolism in insects: synthesis of potential metabolites and identification of initial *in vitro* biotransformation products. Journal of Agricultural and Food Chemistry, 28: 724–731.

Srivastava S. and Kumar K. (1996) Effect of precocenes on metamorphosis of flesh fly, *Sarcophaga ruficornis*. F. Indian Journal of Experimental Biology, 34: 547–553.

Srivastava U. S. and Gilbert L. I. (1969) The influence of juvenile hormone on the metamorphosis of *Sarcophaga bullata*. Journal of Insect Physiology, 15: 177–189.

Wilson T. G., Landers M. H. and Happ G. M. (1983) Precocene I and II inhibition of vitellogenic oocyte development in *Drosophila melanogaster*. Journal of Insect Physiology, 29: 249–254.

Yin Chih-Ming, Zou Bai-Xiang and Stoffolano J. G. (1989) Precocene II treatment inhibits terminal oocyte development but not vitellogenin synthesis and release in the black blowfly, *Phormia regina* Meigen. Journal of Insect Physiology, 35: 465–469.

Zdarek J. and Fraenkel G. (1972) The mechanism of puparium formation in flies. Journal of Experimental Zoology, 179: 315–324.

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Food preferences of a pest grasshopper, *Atractomorpha crenulata* (Fabr.) (Orthoptera: Acridoidae) from Darjeeling Hill

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ABSTRACT: A laboratory study was made of food preferences of a pest grasshopper, *Atractomorpha crenulata* (Fabr.) from Darjeeling Hill, West Bengal, India. Among 13 plant species of 10 families tested *Daucus carota*, *Adiantun caudatum* and *Hemartheria compressa* were the most preferred. *Bambusa vulgaris* and *Amomum subulatum* were rejected. The study revealed that *A. crenulata* has the potential to become a pest of carrot, potato, wheat, tea, raya, onion, maize, squash and pea among the crops and that whip grass and fern may serve as reservoir weeds.
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KEYWORDS: *Atractomorpha crenulata*, grasshopper, food preference, carrot

The grasshopper *Atractomorpha crenulata* (Fabr.), (Orthoptera: Acridoidae) is an important pest of coconut and sugarcane and is found to defoliate *Nicotina tabacum* (tobacco) in India and adjacent countries. It was recorded as a minor pest of paddy, maize and wheat in West Bengal (Mondal *et al.*, 1999). Because of the greater relative abundance of this grasshopper in the Darjeeling Hills of West Bengal, a laboratory study was made of its food preferences.

Adults were collected from fields in Darjeeling, West Bengal (27°13′N, 88°53′E) and kept in wire cages with wooden frame, 75 cm × 40 cm × 30 cm. *Hemartheria compressa* (L.f.), a grass abundant in the habitat of *A. crenulata* was used as a standard (control) food, against which other 12 locally available plants were compared. The grass was selected primarily because of its easy availability. For each set of experiments the cage was supplied with two samples each of four species of plants, including the control, at a time. A total of 50 adult grasshoppers which had been deprived of food for 24 h were used for each set of experiments. Most of the grasshoppers started to feed within 10 min, and most had stopped feeding after an additional 25 min. Each test was repeated three times with fresh samples of

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TABLE 1. Acceptability of selected plant species for feeding by *Atractomorpha crenulata*, in a laboratory study

Plant species & family	Common name	Mean (±SE)% acceptability
Hemartheria compressa (L.f.) (Poaceae)	Whip grass	100
Daucus carota L. (Umbelliferae)	Carrot	201 ± 9
Adiantum caudatum L. (Dryopteridaceae)	Fern	115 ± 10
Solanum tuberosum L. (Solanaceae)	Potato	66 ± 8
Triticum aestivum L. (Poaceae)	Wheat	44 ± 1
Camellia sinensis L. (Theaceae)	Tea	31 ± 4
Brassica caularapa L. (Brassicaceae)	Raya	27 ± 2
Allium cepa L. (Liliaceae)	Onion	25 ± 3
Zea mays L. (Poaceae)	Maize	16 ± 2
Sechium edule (Jacq) Sw. (Cucurbitaceae)	Squash	16 ± 2
Pisum sativum L. (Fabaceae)	Pea	11 ± 1
Bambusa vulgaris Schrad. (Poaceae)	Bamboo	2 ± 3
Amomum subulatum Roxb. (Zingiberaceae)	Cardamom	1 ± 1

grasshoppers and plants. Counts of grasshoppers feeding on plants were taken after three consecutive 5 min intervals. After that, the positions of the plant samples were changed, and three counts were taken again. The order of preference for each plant was determined by assuming the number of adults feeding on the standard plant to be 100 and calculating the corresponding number of adults feeding on other plants (Haldar *et al.*, 1995).

The acceptance values of the tested plants are shown in Table 1. The study revealed that *Daucus carota* and *Adiantum caudatum* were more acceptable to the grasshopper than the control, *Hemartheria compressa*, with mean acceptance values of 201 and 115, respectively. Other acceptable plants were *Solanum tuberosum, Triticum aestivum, Cammelia sinensis, Brassica caularapa, Allium cepa, Zea mays, Sechium edule* and *Pisum sativum*. Two species, *Bambusa vulgaris* and *Amomum subulatum*, were totally rejected after initial nibbling.

The present study reveals that *A. crenulata* has the potential to become a pest of carrot, potato, wheat, tea, raya, onion, maize, squash and pea among the crops and that whip grass and fern may serve as reservoir weeds. The susceptibility of wheat and maize has already been recorded, as noted earlier.

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REFERENCES

Haldar P., Bhandar K. P. and Nath S. (1995) Observations on food preferences of an Indian grasshopper, *Acrida exaltata* Walker (Orthoptera: Acrididae: Acridinae). Journal of Orthoptera Research, 4: 57–59.

Mondal S. K., Hazra A. K. and Tandon S. K. (1999) *Records of the Zoological Survey of India*, Zoological Survey of India, Kolkata, 9–12.

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Insect pests of Ashwagandha, *Withania somnifera* Linn. in tarai region of Uttarakhand

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ABSTRACT: Insect pests associated with the medicinal plant, *Withania somnifera* at Pantnagar, India was investigated. Four major pests, *viz. Helicoverpa armigera* (Lepidoptera: Noctuidae), *Epilachna viginctioctopunctata* (Coleoptera: Coccinellidae), *Myzus persicae* (Hemiptera: Aphididae) and *Tricentrus bicolor* (Hemiptera: Membracidae) were found associated with the crop. The period and intensity of infestation of each pest are reported. © 2009 Association for Advancement of Entomology

KEYWORDS: *Withania somnifera*, *Helicoverpa armigera*, *Myzus persicae*, *Epilachna viginctioctopunctata*, *Tricentrus bicolor*

Ashwagandha, *Withania somnifera* Linn. (Solanaceae) is a herb and all parts of the plant are used in Ayurvedic medicines. Insect pests recorded on this plant include *Epilachna vigintioctopunctata* in Uttar Pradesh and Madhya Pradesh (Anonymus, 2006; Chandra and Chandra, 2004), *Spilarctia obliqua* and *Tricentrus bicolor* in Madhya Pradesh (Chandra and Chandra, 2004) and *Myzus persicae* in Rajasthan (Chandra and Kuswaha, 1986). The present study was undertaken to record the pest complex of *W. somnifera* in Uttarakhand and their time of activity.

The observations were made at the Medicinal Plant Research and Development Centre, G. B. Pant University of Agriculture & Technology, Pantnagar during 2003–05. A crop of *W. somnifera* was raised in eight replicated plots each measuring 4.2 m × 5 m and maintained from October to May 2003–04 and 2004–05, following the recommended management practices. Five plants were selected in each replication and number of infested plants and number of various insects occurring on the plant were recorded at weekly interval commencing from the 2nd week of December.

The data are presented in Table 1 and the highlights are described below.

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TABLE 1. Percent of plants affected by insect pests of Ashwagandha and the number of insects per plant

Period	*H. armigera*		*E. viginctioctopunctata*		*M. persicae*		*T. bicolor*	
	Mean % of plants infested	Mean No. of insects/plant	Mean % of plants infested	Mean No. of insects/plant	Mean % of plants infested	Mean No. of insects/plant	Mean % of plants infested	Mean No. of insects/plant
Dec 2nd wk	0	0	0	0	0	0	0	0
Dec 3rd wk	0	0	0	0	3.71	0.21	4.67	0.31
Dec 4th wk	0	0	0	0	16.60	1.53	15.62	1.58
Jan 1st wk	0	0	0	0	19.47	5.41	18.91	1.82
Jan 2nd wk	0	0	0	0	34.49	7.74	22.46	2.64
Jan 3rd wk	0	0	0	0	60.01	11.31	21.41	2.54
Jan 4th wk	0	0	2.68	0.03	71.84	9.73	19.74	2.92
Feb 1st wk	0	0	7.89	0.10	65.40	5.67	10.47	2.02
Feb 2nd wk	9.87	0.12	32.49	0.54	62.74	3.06	5.39	1.15
Feb 3rd wk	16.61	0.31	47.22	1.55	57.03	2.43	2.3	0.52
Feb 4th wk	20.35	0.51	58.36	2.04	53.09	2.02	1.16	0.04
Mar 1st wk	31.36	1.02	70.52	3.01	40.71	2.33	0.61	0.02
Mar 2nd wk	40.66	1.40	78.81	6.68	14.74	0.61	0	0
Mar 3rd wk	41 45	1.48	96.25	6.86	2.38	0.03	0	0
Mar 4th wk	45.05	1.90	100	5.74	0.83	0.01	0	0
Mar 5th wk	51.23	1.91	100	4.02	0	0	0	0
Apr 1st wk	73.01	2.03	100	2.89	0	0	0	0
Apr 2nd wk	78.78	1.56	100	2.31	0	0	0	0
Apr 3rd wk	75.73	1.52	90.32	1.23	0	0	0	0
Apr 4th wk	38.41	0.65	70.64	0.86	0	0	0	0
May 1st wk	13.96	0.10	15.05	0.15	0	0	0	0
May 2ndwk	2.25	0.02	1.11	0.03	0	0	0	0
May 3rd wk	0	0	0	0	0	0	0	0

In both the years, sowing of crop was in 3rd week of October and observation commenced by 2nd week of December. The number of insects per plant shown is the mean for the years 2003–04 and 2004–05.

Helicoverpa armigera Hübner (Lepidoptera: Noctuidae)

The infestation started in the 2nd week of February and reached to its peak in the 2nd week of April with 78.78 per cent of plants infested, and then declined gradually. At peak infestation, there were 2.03 larvae per plant in 1st week of April.

Epilachna vigintioctopunctata Fabr. (Coleoptera: Coccinellidae)

E. vigintioctopunctata infestation started in the last week of January and the highest infestation (100%) was recorded from 4th week of March to 2nd week of April. At peak infestation there were 6.86 beetles per plant in 3rd week of March. The most favorable period for *E. vigintioctopunctata* infestation was the reproductive stage of the crop after the 1st week of March. Muthukumar and Kalyanasundaram (2003) reported peak incidence of *E. vigintioctopunctata* on Aubergine from March to April.

Myzus persicae Sulzer (Hemiptera: Aphididae)

The infestation of *M. persicae* started from 3rd week of December which increased gradually and reached its peak of 71.84 per cent in the last week of January. The highest number of 11.30 insects per plant was observed in 3rd week of January. Chandra and Kushwaha (1986) observed that the incidence of *M. persicae* and *Lipaphis erysimi* occurred throughout the year on some food plants and from May to July on *W. somnifera*.

Tricentrus bicolor Dist. (Hemiptera: Membracidae)

T. bicolor infestation started in the 3rd week of December and reached its peak in the 2nd week of January with 22.46 per cent of the plants infested. The highest number of 2.92 insects per plant was observed in the last week of January. The favourable period for *T. bicolor* infestation was the vegetative stage of the crop after the 2nd week of January to 1st week of February.

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REFERENCES

Anonymus (2006) Herbal and biological control of lady bird beetle in Ashwagandha. In: *Annual report, 2005-06*, CIMAP, Lucknow, p 4.

Chandra R. and Chandra R. (2004) Status of medicinal plants with respect to infestation of insect pests in and around Chitrakoot, District Satna (M.P.). Flora and Fauna, 10(2): 88–92.

Chandra S. and Kushwaha K. S. (1986) Impact of environmental resistance on aphid complex of cruciferous crops under the Agroclimatic conditions of Udaipur. Indian Journal of Entomology, 48(4): 495–514.

Muthukumar M. and Kalyanasundaram (2003) Influence of biotic factors on the incidence of major insect pests in brinjal (*Solanum melongena* L.). South Indian Horticulture, 51(1): 214–218.

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Starvation impact on venom quantity of a reduviid predator, *Catamirus brevipennis* (Servile) (Hemiptera: Reduviidae)

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ABSTRACT: The effect of starvation on the venom production by the salivary gland of *Catamirus brevipennis* Serville (Hemiptera: Reduviidae) was studied by milking method. Female yielded more venom than the male. Both in male and female the venom yield was higher after two days of starvation.
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KEYWORDS: hunter reduviid, venom quantity, starvation, *Catamirus brevipennis*

Hunter reduviids (Hemiptera: Reduviidae) are considered as effective biological control agents against several agricultural pests (Ambrose, 1999; Grundy and Maelzer, 2000; Sahayaraj, 2006). *Catamirus brevipennis* (Serville), a member of this group distributed in scrub jungles, semiarid zones, tropical rain forest and agroecosystems of south India (Sahayaraj, 2006) feeds on a wide range of insect pests including *Helicoverpa armigera* (Hubner) (Bhatnagar *et al.*, 1983), *Mylabris pustulata* (Faust) (Ambrose, 1999) and *Spodoptera litura* (Fab.) (Sahayaraj, 2006). Reduviid predators kill their prey by injecting toxic salivary venom. This venom consists of a complex mixture of components that include protein, peptides, enzymes and other active biomolecules of biological importance. The reduviid venom has a notable potential for use in agriculture and medicine. Three methods are commonly used for collecting venom: whole body extraction (Ambrose and Maran, 1999; R.-x. Yu *et al.*, 2007), electro stimulation (Alfredo *et al.*, 2000) and milking (Deyrup and Matthews, 2003; Sahayaraj *et al.*, 2006). Maran (1999) showed that prey-deprived *Rhynocoris* spp. possessed more quantity of venom. The objective of the present study was to evaluate the venom load of male and female *C. brevipennis* and the impact of prey deprivation on the same.

C. brevipennis life stages were collected from Sivanthipatti agroecosystems, Tirunelveli, Tamil Nadu and were maintained in plastic containers (6 cm × 15 cm)

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TABLE 1. Impact of starvation on animal weight and venom milked by *C. brevipennis*

Starvation period (d)	Animal weight (mg)		Quantity of venom milked (μl)	
	Male	Female	Male	Female
0	523.12 ± 0.06	675.43 ± 0.02	0.10 ± 0.02[a]	0.11 ± 0.01[a]
1	510.10 ± 0.01	630.13 ± 0.01	0.12 ± 0.00[ab]	0.19 ± 0.04[b]
2	480.42 ± 0.01	550.17 ± 0.02	0.22 ± 0.02[c]	0.27 ± 0.01[c]
4	470.01 ± 0.01	520.20 ± 0.01	0.19 ± 0.03[d]	0.24 ± 0.01[d]
7	470.00 ± 0.01	520.05 ± 0.01	0.12 ± 0.01[abe]	0.19 ± 0.01[be]
8	470.00 ± 0.01	490.13 ± 0.00	0.04 ± 0.01[f]	0.08 ± 0.02[f]

In a column, means followed by same alphabets are not significantly different at 5 % level using DMRT.

with *Corcyra cephalonia* (Stainton) fifth instar larvae as food, under laboratory conditions (R. H. 75–85%, temperature 27–31 °C and photoperiod 13L and 11D h). Laboratory emerged *C. brevipennis* male (410–590 mg) and female (450–690 mg) were kept separately in plastic boxes (7 cm × 6 cm) and fed with *C. cephalonica* for two weeks continuously. Ten each male and female were randomly selected from the laboratory culture and starved for one, two, four, seven and eight days, separately. Venom was milked using capillary tube as described by Sahayaraj *et al.* (2006), collected in a Hamilton syringe (Switzerland), and expressed in μl per animal. Both the weight of the animal and of the milked venom were determined. The mean value of venom yield in the control (unstarved) animal was compared with that of animals starved for different periods. The significance of the differences was tested using Duncan's Multiple Range Test, at 5% level of significance.

The milking method proposed by Sahayaraj *et al.* (2006) for venom collection from reduviids was found to be suitable for venom collection. *C. brevipennis* female milked more venom (1.86 ± 0.35 mg) than the male (1.56 ± 0.32 mg). Ambrose (1999) and Sahayaraj (2006) reported that the female reduviids paralyzed the preys quicker than males and suggested that presence of more quantity venom in the reservoirs could be the reason for this.

On starvation, both in male and female, the venom quantity increased up to two days and then gradually decreased up to eight days of starvation (Table 1). Up to the eight days of starvation, none of the starved insects died but there was progressive weight loss, although in male the loss in weight was negligible after four days.

Ambrose and Maran (1999) reported that in *Acanthaspis pedestris* the quantity of saliva present in both anterior and posterior lobe increased when subjected to prey deprivation. It was reported that prey deprivation causes accumulation of toxic saliva in the salivary glands (Ambrose, 1999). If more saliva (venom) was accumulated during the course of starvation, the insect should yield more quantity of venom during milking. In contrast, venom quantity was negatively correlated with starvation. This shows that venom has not been accumulated; rather it may have been concentrated due

to re-absorption of water during starvation. It was reported that in starved reduviids the paralyzing time was gradually diminished when prey deprivation time extended.

Our results show that *C. brevipennis* starved for two days can be used for venom collection.

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REFERENCES

Alfredo Torres-Larios, Georgina B. Gurrola, Fernando Z., Zamudio D. Possani and Lourival (2000) Hadrurin, a new antimicrobial peptide from the venom of the scorpion *Hadrurus aztecus*. European Journal of Biochemistry, 267: 5023–5031.

Ambrose D. P. (1999) *Assassin Bugs*, Science Publishers, New Hampshire, USA, 153–170.

Ambrose D. P. and Maran S. P. M. (1999) Quantification, protein content ad paralytic potential of saliva of fed and prey deprived reduviid, *Acanthaspis pedestris* Stål (Heteroptera Reduviidae: Reduviinae). Indian Journal of Environmental Sciences, 3(1): 11–16.

Bhatnagar V. S., Sitanathan S., Pawer C. S., Jadhav D., Rao V. R. and Reed W. (1983) Conservation and augmentation of natural enemies with reference to integrated pest management in chickpea (*Cicer arietinum* L.) and pigeonpea (*Cajanus cajan* L.) Mill sp. In: *Proc. Int. Workshop on Intergrated Pest Control for Grain Egume – Goiania Oia's*, Brazil, Eds, 57–180.

Deyrup L. D. and Matthews R. W. (2003) A simple technique for milking the venom of a small parasitic wasp, *Melittobia digitata* (Hymenoptera: Eulophidae). Toxicon, 42(2): 217–218.

Grundy R. P. and Maelzer D. (2000) Predation by the assassin bug *Pristhesancus plagipennis* (Walker) (Hemiptera: Reduviidae) of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) and *Nezara viridula* (L.) (Heteroptera: Pentatomidae) in the laboratory. Australian Journal of Entomology, 39: 280–282.

Maran S. P. M. (1999) Chosen reduviid predators – prey interaction, Nutritional and Kairamonal Chemical Ecology *Ph.D, Thesis*. Manonmaniam Sundarar Universty, p 111.

Sahayaraj K. (2006) *Pest Control Mechanism of Reduviids*, Oxford Book Company, Jaipur, India, 105–110.

Sahayaraj K., Muthu Kumar S. and Prem Anandh G. (2006) Evaluation of milking and electric shock methods for venom collection from hunter reduviids. Entomon, 31(1): 65–68.

Yu Rui-xian, Ya-Feng Chen, Xue-xin Chen, Fang Huang, Yong-gen Lou and Shu-sheng Liu (2007) Effects of venom/calyx fluid from the endoparasitic wasp *Cotesia plutellae* on the hemocytes of its host *Plutella xylostella in vitro*. Journal of Insect Physiology, 53: 22–29.

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Jalaja M., Muraleedharan D. and Prabhu V. K. K. (1973) Effect of extirpation of median neurosecretory cells on reproduction in the female red cotton bug, *Dysdercus cingulatus*. Journal of Insect Physiology, 19(1): 29–36.

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